# WATER QUALITY RESEARCH--THE PRESIDENT'S INITIATIVE

## PROGRAM REVIEW AND EVALUATION,1991

## COMPREHENSIVE
## REPORT

### PART I. PRIORITY COMPONENTS

Agricultural Research Service
Cooperative State Research Service
U.S. Department of Agriculture

in
Cooperation
with

State Agricultural Experiment Stations
and collaborators

### PART II. SELECTED GEOGRAPHIC SYSTEMS

Management Systems Evaluation Areas (MSEA)

Agricultural Research Service
Cooperative State Research Service
U.S. Department of Agriculture

in
Cooperation
with

State Agricultural Experiment Stations
U.S. Geological Survey
Environmental Protection Agency

## ACKNOWLEDGEMENT

Many people contributed to the success of the 1991 evaluation and review processes on progress of water quality research programs supported largely by FY 1990 funds from the President's Initiative.

The review of Components Research was organized through efforts of the North Central NCS-5 and the Northeast NEC-61 research coordinating committees, with J. F. Bartholic, Michigan State University (MSU) and H. B. Pionke, ARS/USDA, University Park, Pennsylvania as co-chairs, respectively. MSU hosted the workshop. Also, representatives of CSRS, ARS and other state and federal agencies, and administrative advisors C. R. Krueger (NEC-61) and D. H. Vanderholm (NCS-5) gave valuable assistance.

Members of the Evaluation Panel for Priority Components projects are listed on page 29 of the Comprehensive Report. They prepared reports for their respective Research Problem Areas and Work Groups, which constituted PART I of the Comprehensive Report.

Evaluation and onsite reviews of the five MSEA projects of the Midwest Initiative were planned and carried out by representatives of CSRS, ARS, USGS, and EPA with input from other USDA and state agencies. A table showing participants in the Evaluation Teams for the MSEA is given on page 72. A draft MSEA report was prepared by team members, D. A. Bucks, M. L. Horton, and H. Mattraw. It was edited by D. R. Kincaid, ARS.

The Comprehensive Report and the Summary were coordinated and edited by C. M. Smith, Visiting Professor, Pennsylvania State University.

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## FOREWORD

The use of pesticides, fertilizers, manures and wastes contributes substantially to the productivity and efficiency of agriculture and, in turn, to the well-being of rural and urban communities throughout the world. There are concerns, however, about contaminant risk to human health, water quality in general, and for an ecologically stable environment. The President's Initiative on Enhancing Water Quality was initiated in 1990 to provide new emphasis on the protection of the environment and the conservation and wise use of our natural resources.

The need for a major research effort on contaminants and associated potential problems was recognized. A research plan was developed jointly by the Agricultural Research Service and the Cooperative State Research Service, with major contributions from the State agricultural experiment stations (SAES) and other agencies of the Department. An effective partnership has been accomplished through collaborative administrative and research efforts with the U.S. Geological Survey, the Environmental Protection Agency, and state groups including SAES. The research plan addresses two types of research: **Priority Components** and **Selected Geographic Systems**--Management Systems Evaluation Areas (MSEA).

As a result of this review and evaluation, changes in the **Priority Components** are being made: 1. The research program will place greater emphasis on socioeconomic research. The lack of understanding of the impact of groundwater and surface water quality issues on economics and State, county and local-government policy was apparent. 2. The research program will place more emphasis on nitrates in groundwater. All aspects of nitrogen management are under review and improved soil tests for nitrogen are being evaluated for efficacy, in a national study. 3. An expanded effort on pesticide contamination of surface waters is being planned based on recent findings. New or modified pesticide management practices are needed for both groundwater and surface water protection.

The **Selected Geographic Systems** program was in early stages of implementation during its review and many recommendations of the review team have been readily incorporated. The extension of the results from the five major projects--MSEA--to the entire Midwest is essential. The research scientists will be working with education and technology transfer specialists in the Midwest region to develop more specific plans for achieving this goal.

Outstanding research efforts are underway in both programs. The knowledge developed over the next few years will greatly enhance our understanding of the fate and transport of potential contaminants in soils and water and enable the design and adoption of economical and environmentally acceptable agricultural production systems.

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Cooperative State Research Service

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National Program Leader, Water Quality
Agricultural Research Service

Co-Chairs, Research and Development Committee

# WATER QUALITY RESEARCH: THE PRESIDENT'S INITIATIVE
# PROGRAM REVIEW AND EVALUATION, 1991

## SUMMARY

### BACKGROUND

The deterioration of water quality or the potential for it, resulting from the use in agriculture of certain pesticides, fertilizers, manures, sludges, and other management practices, is a problem of major concern to rural and urban people and scientists. Research in agriculture to obtain the needed understanding of what happens to chemicals and other products in soils and water, and the development of technologies to avoid excessive concentrations of potential contaminants or to remediate problem conditions, was given major impetus by new emphasis on water quality in the statement of an Initiative by The President.

"The protection of the environment and the conservation and wise management of our natural resources must have a high priority on our national agenda. But given sound research, innovative technology, hard work, sufficient public and private funds, and--most important of all--the necessary political will, we can achieve and maintain the environment that protects the public health and enhances the quality of life for us all." *President George Bush*, "Building a Better America," February 9, 1989.

This document also gave three principles as the basis for the Initiative, as follows:

"The President is committed to protecting the Nation's groundwater resources from contamination by fertilizers and pesticides without jeopardizing the economic vitality of U.S. agriculture.

"Water quality programs must accommodate both the immediate need to halt contamination and the future need to alter fundamental farm production practices.

"Ultimately farmers must be responsible for changing production practices to avoid contaminating ground and surface waters. Federal and state resources can provide valuable information and technical assistance to producers so that environmentally sensitive techniques can be implemented at minimum cost."

### OBJECTIVES

#### USDA Water Quality Research Objectives

The objectives are from two sources:

USDA Research Plan for Water Quality, January, 1989

1. Document the sources and amounts of potentially hazardous contaminants in groundwater which are attributable to current agricultural and forestry practices, and identify the basic processes involved in their movement through soil and into groundwater.

2. Develop new field and laboratory methods for rapidly, reliably, and inexpensively analyzing pesticide residues and for determining the rates at which water and chemicals move through soils to groundwater.

3. Develop new and modified crop and livestock production systems that substantially decrease the movement of potentially hazardous chemicals into groundwater, and determine the effects of these new systems on farm costs, changes in farm inputs, and production choices.

4. Develop simple, inexpensive, onfarm methods for disposing of pesticide containers and other hazardous wastes without contaminating groundwater.

5. Develop decision-aid systems that may be used by technical and farm management specialists, Extension agents, and farm consultants to help individual farmers select, apply, and manage profitable and environmentally sound crop and livestock production practices.

6. Evaluate the economic, social, and political impacts of alternative crop and livestock production systems, policies, and institutional strategies to control groundwater contamination.

USDA Water Quality Initiative 1991 Work Plan

1. To improve and expand our knowledge of agricultural practices related to water quality.

2. To integrate that knowledge into the development of improved agricultural chemical and production management systems.

3. To do this (1,2) using economically and environmentally sound practices.

Program evaluation, through reporting and planning conferences, was specified in the USDA Research Plan for Water Quality (1989), the Water Quality Program Plan to support the Initiative (1989), and the 1990 and 1991 USDA Water Quality Initiative Work Plans. A separate onsite review and evaluation of the five MSEA projects is given as PART II.

All projects are considered as a total program of interrelated water quality research. The U.S. Department of Agriculture (USDA) Research Plan for Water Quality (1989) set up a structure with two general types of research activities. One type designated as PART I. Priority Components research includes a wide range from fundamental laboratory and field research to applied types of technology-driven studies, concentrating on parts or "components" of processes, practices, or systems. The other type in the 1989 Plan, PART II. Selected Geographic Systems, is represented by the Management Systems Evaluation Areas (MSEA) begun in 1990. This research focuses on developing and evaluating agricultural production systems comprised of feasible combinations of results from components research of PART I.

## PART I. PRIORITY COMPONENTS

### INTRODUCTION

A water quality research program review and evaluation of activities, funded as USDA grants and awards under the President's Initiative, was participated in by 63 federal, university, and independent scientists and 28 evaluators, observers, and speakers. Fifty-eight projects of the Agricultural Research Service (ARS), Cooperative State Research Service (CSRS) and State Agricultural Experiment Stations (SAES) and collaborators constituted the accelerated and new water quality program being evaluated. In addition to these agricultural research organizations, participation included the Extension Service (ES), Soil Conservation Service (SCS), U.S. Geological Survey (USGS), industry and the private sector. Additional participants were invited.

### EVALUATION and WORKSHOP OBJECTIVES

**Exchange scientific and technical information** among principal investigators, other researchers, program managers, and users of information.
**Evaluate progress, collaboration, and coordination** in USDA-funded research programs.
**Identify significant results** and new developing opportunities for collaboration with related programs.
**Identify promising agricultural production** and management systems and technologies.

## PLAN and PROCESS

States in the North Central and Northeast Regions were involved in the July 23-25, 1991 workshop/conference at East Lansing, Michigan. Principal investigators of all projects receiving Initiative funding in FY 1990, and relevant funding in FY 1989, were requested to prepare an abstract and report of progress, display and discuss a poster of research results and future plans, and participate in a working group(s) to discuss accomplishments and to cooperatively develop priorities of problems needing solution to meet the goals and objectives of the Initiative. Scientists in the West and South Regions, who received Initiative funds, also prepared abstracts of progress which were assembled in a national report. Those regions will have evaluations like East Lansing in the spring of 1992.

An Evaluation Panel, with an expert in each water quality Research Problem Area (RPA), was selected from outside the North Central and Northeast Regions, except for the Social Sciences RPA. Panelists were responsible for an evaluation of Initiative water quality materials prepared for the workshop/conference which served as the baseline for scientist debates within the individual workshops. Guidelines for the Panel and Workshops are detailed in the comprehensive report. Recommendations will be utilized by CSRS and ARS in setting priorities for funding water quality projects in FY 1992 and later years.

The Workshops were organized by general RPA which were: Chemical Fate and Transport; Transformation and Remediation--Pesticides, other Organics and Microbes; Nitrogen, other Nutrients, Wastes, and Metals; Production Management Systems; Social Sciences; and Education and Technology Transfer which interacted with each RPA and included "users" of information representing ES, SCS, the private sector, and industry.

## EVALUATION and WORKSHOP RESULTS

The Initiative program has funded excellent research at a number of Land Grant Universities, ARS laboratories, and private foundations of the North Central and Northeast regions of the country. The principal investigators are well qualified, the overall quality of research is high, and the projects address a broad range of problems from both a subject matter and geographic viewpoint. The investigators are using "cutting edge" analytical and experimental methods. Numerous projects have made advances that can have an immediate impact on enhancing groundwater quality.

The scientists' reports for the program evaluation were based on only 6 to 18 months of results from 2 or 3-year projects funded by the President's Initiative on Water Quality. Movement and degradation of pesticides is usually a long-term problem, the solution of which requires an investment in long-term research activities. The research reported here utilized fundamental and applied methods to learn about the behavior of pesticides in soil and water. Emphasis was on widely used chemicals or ones having been detected in groundwater. Studies on atrazine, for example, yield information that can be used for extrapolation to the behavior of related pesticides such as triazines.

Details of work group actions are given in a separate comprehensive report containing program evaluation information and recommendations of research needs that may require special attention to obtain acceptable proposals. Also, certain problem areas are recommended for increased emphasis to reflect the impact of research already underway.

## State of Component Research

**INFORMATION CONTAINED IN THIS REPORT IS CONSIDERED PRELIMINARY AND THE PRINCIPAL INVESTIGATORS SHOULD BE CONTACTED FOR DETAILS AS TO INTERPRETATION AND USE.**

**Ready for technology transfer**--Those items designated with an **asterisk(*)** are considered ready for use and/or for adaptive research and demonstration, when results are compared among locations.

### Fate and Transport

Research quality is good to excellent and relevant to objectives, as indicated by research reports and posters. Progress was good. Emphasis is on fundamental research and over somewhat small scales of space and time. There is a need for identification of component research as part of the larger picture. Some general conclusions:

***Timing of pesticide contact with soil as related to transport** and method of application is very important concerning transport through and degradation in the root zone. A delay in irrigation or rain after application of pesticides can reduce chemical movement.
**Sorption rates and relative mobility** are reasonably predicted given soil and pesticide properties, but extrapolation from laboratory derived values to field applications can be difficult.
**Preferential flow is widespread** in many soils and is a major factor in the movement of chemicals to groundwater along pores, cracks, or channels.
**Frost and winter conditions** are related to some of the highest concentrations of nitrate and flow rate from the subsurface.
**Nitrogen and nutrient movement** generally should be characterized and studied separately from pesticides.

### Transformation and Remediation: Pesticides, other Organics

***Treatment of wastes**--Methods for onfarm use that degrade potentially toxic pesticide wastes to non-toxic byproducts.
***Baits**--Baits amended with an insecticide for control of corn rootworm larvae can control the pest and reduce insecticide use by 98%.
***Analytical methods**--Dramatically more economical methods for extraction and analysis of pesticides have been developed.
**Remediation**--Rapid decomposition of pesticide in pure microbial systems has been shown.
**Microbial processes**--Enhanced degradation of pesticides occurs in soil adjacent to plant roots.
**Starch encapsulation**--The encapsulation of pesticides, for comparable cost, can reduce leaching, lower rates, and improve handling--needs industrial support and adaptive research and demonstration.

### Nitrogen, other Nutrients, Wastes, Metals

***Information is available for a "white paper"** on the nitrate required in root zones of crops for satisfactory yields, and how much could leach to ground water even with best management practices.
**Sources of N contamination**--Projects include management and transformations for major N sources as poultry and dairy manures, fertilizers, and legumes.
**Avoidance techniques**--N use-efficiency to reduce nitrate buildup in soils: correlate rate and time of application with plant needs.
**Amelioration strategies**--Scavenging by deep-rooted crops, N immobilization and denitrification changes from nitrate, and plant uptake of residual or excess nitrate.

***Detection and diagnostic procedures for N sufficiency**--Substantial improvement in soil, plant tissue, and chlorophyll testing to improve N-use efficiency.

**Note**: Soil testing for residual nitrate to depths of 2 to 4 ft has been widely used for N fertilizer recommendations in rainfall-limiting areas of the Great Plains, the Northwest, the Rocky Mountain States, and certain other areas for 20 to 35 years. This provides a background of valuable information and experience on which to build a successful program in the humid areas of the country.

**A successful N-management system**--Requires transformation/transport information on N sources, N needs at different periods of plant growth for different soils, cropping history, weather records and precipitation probabilities.

Production Management Systems

This type of research is nearly always long term because of the need to evaluate combinations of crops and management for different soils and weather. Systems research is presented largely in Part II of this report; however, several efforts are underway to broaden the scope of small systems so they may be combined for field, watershed and large scale use. Considerable applicable research is underway on practices that are used to comprise systems and results will be used as soon as available.

**Soil, crop, and chemical management practices**--ridge tillage, irrigation management to reduce chemical flux below the root zone, water table management, reduction of chemical use.
**Decision aid systems and models**--development and application research.
**Support for decision aids and models**--large data and information bases, incorporation of fate and transport models, decision criteria.
**Methodologies for risk assessment**--climate effects and timing of operations.

Social Sciences

The few projects now underway supported by the water quality Initiative are too limited to answer complex but relevant questions, although the number of social sciences-type proposals has increased over a 3-year period. It is not the lack of challenging research topics; there has been a shortage of relevant high quality economics, sociology, and other social sciences proposals. The number of such projects must be increased or badly needed information will be obtained too late for correct interpretation of physical and biological sciences data on water quality.

Education and Technology Transfer

Across the range of applied studies on water quality, strong linkages between research and Extension and SCS are requirements of effective education and technology transfer programs. Opinions in this group varied widely as to the effectiveness of present technology transfer efforts, from nearly all to a little relevant technology being effectively transferred.

**Technology transfer is broadly defined** to include extension information and education, outreach, public service and public relations.
**The "users" of research information** range from farmers and agricultural producers, agribusiness, governmental agencies, elected officials, special interest groups, and the general public.
**Technology transfer is most critical in the midpoint region of a continuum in scientific inquiry** from fundamental research, through applied and adaptive research, to demonstration or observational trials at the other extreme.

## COMMENTS

The Review and Evaluation Panel complimented the participants on their cooperation in the evaluation process and the excellent posters which displayed progress of their research, and served as the basis for constructive discussions. The scientists working in PART I, Components Research, welcomed the opportunity to present preliminary results, gain from the interaction with other researchers, and critique the work displayed by their peers. Benefits from the exchange of ideas, recognition of trends in research results, and the realization that they and users of information are a part of the evaluation and planning process, were among the positive comments.

# PART II. SELECTED GEOGRAPHIC SYSTEMS
## Management Systems Evaluation Areas (MSEA)

## INTRODUCTION

Comprehensive studies for evaluation of agricultural production management systems and their water quality impacts have been initiative in five Management Systems Evaluation Areas(MSEA) projects. The lead states are Iowa, Minnesota, Missouri, Ohio, and Nebraska, with field satellite locations in North Dakota, South Dakota, and Wisconsin. In addition to the agricultural experiment stations of these states, the MSEA projects include ARS, CSRS, USGS, EPA, ES, SCS, and other state and federal agencies.

The USDA Working Group on Water Quality asked its Research and Development Committee to implement evaluation of progress and organizational structure of the MSEA program begun in 1990. The MSEA "Systems" program is a part of the USDA Midwest Initiative on Water Quality, which includes relevant USDA and SAES Components projects, the USGS Midcontinent Herbicide Initiative and, beginning in 1992, the EPA Midwest Agrichemical Surface-Subsurface Transport and Effects Research (MASTER) program. This evaluation report of the overall MSEA program and the five MSEA projects, reflecting onsite inspections in June 1991 by a review team of well qualified experts, is Part II of the comprehensive evaluation report on the USDA Water Quality program for 1991.

The MSEA projects are cooperatively administered by ARS, CSRS, SAES, and other collaborating agencies through appropriate committees and subcommittees, as outlined in the USDA Research Plan for Water Quality (1989). Broad program oversight and coordination is provided by the Research and Development Committee, with onsite guidance by a MSEA Management Team consisting of representatives of participating agencies. A MSEA Steering Committee, composed of Principal Investigators from the five areas, contributes to the infrastructure of the project and receives guidance and recommendations from the Management Team. The Steering Committee also is supported by technical subcommittees. The research initiated relates directly to the general and specific objectives of the 1989 Plan, and the objectives of the 1991 Initiative Plan.

## EVALUATION OBJECTIVES

**Evaluation of the MSEA research plans** and, if appropriate, recommend changes in the individual projects and the overall program.

**Evaluate progress, collaboration, and coordination** in the interagency funded research program.

**Identify research gaps and opportunities.**

**Assess interest and need** to continue and expand the research program in the future.

**Enhance communication** on feasibility for regionalization of the research program.

## PLAN and PROCESS

The Research and Development Committee convened an overview meeting at Columbus, Ohio, on June 3 and 4, 1991 to review progress on project integration by MSEA project administration and technical subcommittees. An additional aspect was to develop an understanding of the complex administration of research activities and identify appropriate cross-site capability for documenting regional patterns.

The review and evaluation of the overall MSEA program and all MSEA field research sites occurred over a 3-week period from June 3 to 21, 1991. The review team was comprised of representatives of the four principal Federal agencies--ARS, CSRS, USGS, and EPA, and additional agency and university specialists and scientists from the Economic Research Service, SCS, Extension Service, Montana State University, Georgia Agricultural Experiment Station, North Carolina State University, and the University of Kentucky. Names and other details are given in the comprehensive report.

## EVALUATION RESULTS

### State of MSEA Program

A number of field and watershed scale management projects have been developed or re-focused in MSEA to address specific management practices. This is a prime example of excellent cooperation and collaboration in research among states and agencies. At this stage, completion of planning, development of coordination within and among the various entities, instrumentation and initiation of field research is a success story. Considerable effort has been expended in project selection and development of technical subcommittees and their coordination functions across all five MSEA.

#### MSEA Subcommittee Structure

Management Systems--Cropping systems were developed to address ground and surface water contamination problems specific to each MSEA area, with emphasis on a reference system widely used in the region. The review team believed that additional management systems should be evaluated if additional funding becomes available and the MSEA are extended for a longer time.

Quality Assurance/Quality Control--QA/QC has effectively developed procedures for individual laboratories for analysis of soil and water samples and an external evaluation of QA/QC results.

Decision Aids/Models--Water quality models have been selected for evaluation. Consistent MSEA data and field laboratories will be made available to individuals, agencies, and institutions to test, validate, and improve existing and new models.

Regional Data Management--RDM has completed the tasks of general data handling, data transfer, and data table structure. Specific procedures for regional data analysis and storage, and how to correct deficiencies in the database are being addressed.

Socioeconomics--Socioeconomic survey information will be integrated with models to predict adoption of alternative management systems. Their impact on water quality policy issues is to be resolved. The Team suggested a minimum set of survey questions should be developed for all MSEA that address regional Social Science environmental impacts.

Technology Transfer--This recent Extension educational component will facilitate coordination with other water quality projects and agencies across the Midwest. The review team was complimentary on the potential for training and technology transfer to farmers and the general public.

Ecologic Efforts. Concerned with ecosystem health in terms of fish and wildlife, eroded soils, and recreational benefits and to meet the objectives of MSEA program, the review team suggests relevant research be broadly based across the Midwest.

Program Regionalization, Midwest Initiative

The review team believed a strong effort is needed to develop a coordinated and realistic approach for projecting the benefits of implementing new or modified farming systems beyond the MSEA research program itself. The MSEA could start with a single prototype project that would determine applicability of the research to benefits within areas or regions near each MSEA project. Tasks, abstracted, were identified as follows:

- Name a technical subcommittee to develop an action plan that enhances current MSEA objectives.
- Integrate other agencies into the MSEA regionalization action plan to reduce duplication.
- Develop a risk-based approach for assessing benefits of implementing new or modified farming system.
- Promote regionalization through effective communication and integration among program participants.

## State of Individual MSEA

The review teams were very impressed with the general progress on the field siting and initiation of research supporting the five MSEA, and the organization and operational committee structures of USDA and MSEA. The state of research planning and accomplishments is based on only 10 to 14 months of activities after project awards. All the MSEA projects have prepared a general plan and location brochure and a comprehensive plan is being finalized. Following is abstracted information about each MSEA. Greater detail, including recommendations of the review team intended to strengthen the functioning of the overall and individual MSEA programs of the review team, is in PART II of the comprehensive report.

Iowa MSEA has work underway at three sites: Western region near Treynor, a deep loess soil; northeast region near Nashua on a glacial till, loamy soil; and Central Des Moines Lobe, Walnut Creek watershed, near Boone on a glacial till soil. Stream flow in the Walnut Creek watershed has shown large changes in atrazine and nitrate concentration throughout the year. The Treynor and Nashua sites are building on historical data.

The Minnesota MSEA has sites in four states: The Anoka Sand Plain at Princeton, Minnesota; the Oakes, North Dakota Irrigation Research Area; Big Sioux Aquifer area, Brookings, South Dakota, and the Wisconsin River Sand Plains, Arena, Wisconsin. Impacts of ridge-tillage on transport of atrazine, alachlor, and metribuzin in unsaturated and saturated soil zones is being evaluated at all sites for a corn and soybean cropping system.

The Missouri MSEA in the Goodwater Creek watershed is within a claypan soil region. Mechanisms of movement of agrichemicals over and through a claypan are being determined for different cropping systems.

The Nebraska MSEA is evaluating improved furrow and sprinkler irrigation management systems. Plant tissue testing is being used to schedule fertigation (application of fertilizer through an irrigation system).

Ohio MSEA overlies the Scotio River Buried Valley Aquifer near Piketon, Ohio. Soil and hydrogeological site characterization has been completed and ground water monitoring initiated. Ohio has prepared a number of project documentation manuals.

COMMENTS

A need was identified for an appropriate inventory of the resource base with an assessment of the magnitude and extent of the agricultural water quality problem. In addition, determine applicability and the anticipated extent of adaptability of the research findings, and establish costs and benefits of farmers implementing new alternative production systems in the region.

Significant progress was made at the five MSEA locations during the first year of research and development. The recommendations by the review team were acted upon immediately. The program administrators, review team, and MSEA scientists appreciated the exchange of ideas and the opportunity to recommend improvements in current program operations and the research plans.

## PROGRAM REVIEW AND EVALUATION

## COMPREHENSIVE REPORT

### INTRODUCTION

The deterioration of water quality or the potential for it, resulting from the use in agriculture of certain pesticides, fertilizers, manures, sludges,and other management practices, is a problem of major concern to rural and urban people and scientists. Research in agriculture to obtain the needed understanding of what happens to chemicals and other products in soils and water, and the development of technologies to avoid excessive concentrations of potential contaminants or to remediate problem conditions, was given major impetus by new emphasis in the Water Quality Initiative of President Bush that was first funded in FY 1990.

### USDA RESEARCH OBJECTIVES

The objectives are from two sources:

USDA Research Plan for Water Quality, January, 1989

1. Document the sources and amounts of potentially hazardous contaminants in groundwater which are attributable to current agricultural and forestry practices, and identify the basic processes involved in their movement through soil and into groundwater.
2. Develop new field and laboratory methods for rapidly, reliably, and inexpensively analyzing pesticide residues and for determining the rates at which water and chemicals move through soils to groundwater.
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USDA Water Quality Initiative 1991 Work Plan

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2. To integrate that knowledge into development of improved agricultural chemical and production management systems.
3. To do this (1,2) using economically and environmentally sound practices.

Water Quality program evaluation, through reporting and planning conferences, was specified in the USDA Research Plan for Water Quality (1989), the Water Quality Program Plan to support the Initiative (1989), and the 1990 and 1991 USDA Water Quality Initiative Work Plans. A separate onsite review and evaluation of the five MSEA projects is given as PART II.

All projects are considered as a total program of interrelated water quality research. The USDA Research Plan for Water Quality (1989) set up a structure with two general types of research activities. One type designated as PART I. Priority Components research includes a wide range from fundamental laboratory and field research to applied types of technology-driven studies, concentrating on parts or "components" of processes, practices, or systems. The other type in the 1989 Plan, PART II. Selected Geographic Systems, is represented by the Management Systems Evaluation Areas (MSEA) begun in 1990. This research focuses on developing and evaluating agricultural production systems comprised of feasible combinations of results from components research of PART I.

## PART I. PRIORITY COMPONENTS

North Central and Northeast Regions

East Lansing, Michigan

### INTRODUCTION

A water quality research program review and evaluation of activities, funded as USDA grants and awards under the President's Initiative, was participated in by 63 federal, university, and independent scientists and 28 evaluators, observers, and speakers. Fifty-eight projects of the Agricultural Research Service (ARS), Cooperative State Research Service (CSRS) and State Agricultural Experiment Stations (SAES) and collaborators constituted the accelerated and new water quality program being evaluated. In addition to these agricultural research organizations, participation included the Extension Service (ES), Soil Conservation Service (SCS), U.S. Geological Survey (USGS), industry and the private sector. Additional participants were invited.

Projects funded for FY 1990 were through ARS national research grants and CSRS Special Research Grants. And, because of the closely related FY 1989 Water Quality awards by CSRS, they were included in this evaluation. Program evaluation was proposed in the USDA Research Plan for Water Quality (1989), and the 1990 and 1991 USDA Water Quality Initiative Work Plans. All projects are considered as a total program of interrelated water quality research.

The USDA Research Plan for Water Quality (1989) set up a structure with two general types of research activities. One type was designated as Priority Components research which covers a wide range from fundamental or basic laboratory and field research to applied types of technology-driven and evaluation studies. These projects concentrate on parts or "components" of the larger answers. The other type--Geographic Systems--focuses on evaluation of agricultural production systems, to be conducted on potential problem areas such as corn and soybean in the Midwest. This latter type is represented by the Management Systems Evaluation Areas (MSEA), begun in 1990, which utilize large-scale areas for study. Results of a separate onsite review of the five MSEA projects is given as Part II of this overall report, although some reference is made to the MSEA research in Part I, particularly in the Agricultural Production Systems Work Group.

## EVALUATION and WORKSHOP OBJECTIVES

The water quality research objectives are given in the Summary, page one.

**Exchange scientific and technical information** among principal investigators, other researchers, program managers, and users of information.
**Evaluate progress, collaboration, and coordination** in USDA-funded research programs.
**Identify significant results** and new developing opportunities for collaboration with related programs.
**Identify promising agricultural production** and management systems and technologies.

## PLAN and PROCESS

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An Evaluation Panel, with an expert in each water quality Research Problem Area (RPA), was selected from outside the North Central and Northeast Regions, except for the Social Sciences RPA. Panelists were responsible for an evaluation of Initiative water quality materials prepared for the workshop/conference which served as the baseline for scientist debates within the individual work groups. Guidelines for the Panel and Workshops are detailed in the comprehensive report. Recommendations will be utilized by CSRS and ARS in setting priorities for funding water quality projects in FY 1992 and later years.

The Workshops were organized by general RPA so the expertise and interests of participants were optimized. The RPA were: Chemical Fate and Transport; Transformation and Remediation--Pesticides, other Organics and Microbes; Nitrogen, other Nutrients, Wastes, and Metals; Production Management Systems; Social Sciences; and Education and Technology Transfer, This last group interacted with each RPA and included "users" of information representing ES, SCS, the private sector, and industry. This cross-cutting work group evaluated the response of the Water Quality Program to expected needs for information, and they accordingly made recommendations.

The type of research sometimes designated as "fundamental processes" occurred in each of the five RPA given above, and was not considered as a distinct RPA. Also, methods development was discussed in each RPA, as appropriate. Contamination assessment is often a problem of size scale, sampling strategy, and specialized equipment, with these relating to deterioration of water quality usually through physical movement of potential contaminants; therefore, it was considered in the Fate and Transport RPA.

Panelists for each RPA were responsible for an evaluation of Initiative water quality materials prepared for the workshop/conference which served as the baseline for scientist debates within the individual work groups. They were expected to be familiar with relevant research nationwide, and to prepare a report and recommendations within the respective RPA based on conclusions of the groups. Respective members of the Evaluation Panel guided the discussions within workshops to ensure full coverage of assignments.

Evaluation Panel and Work Group Guidelines

- Appropriate development of program objectives and plans.
- Are the most technically advanced methods being used in the research?
- Interdisciplinary, inter-site and intra-agency coordination: Where appropriate, is it being developed?
- Adequacy of results to determine if water quality can be protected or enhanced.
- Transferability of research results or contamination evaluation methods to:
  - Education and technical assistance agencies, consultants, and farmers.
  - Other areas and regions of the country.
  - Other management conditions and time.
- Identify research problems and opportunities that need a different emphasis to facilitate meeting program goals and objectives and suggest changes of emphasis to meet the needs.

## EVALUATION and WORK GROUP RESULTS

The Initiative program has funded excellent research at a number of Land Grant Universities, ARS laboratories, and private foundations of the North Central and Northeast regions of the country. The principal investigators are well qualified, the overall quality of research is high, and the projects address a broad range of problems from both a subject matter and geographic viewpoint. The investigators are using "cutting edge" analytical and experimental methods. Numerous projects have made advances that can have an immediate impact on enhancing groundwater quality.

The scientists' reports were based on as little as 7 months of results for FY 1990 CSRS awards and about 1 year for ARS. Up to 21 months of 2-year CSRS awards had transpired. Movement and degradation of pesticides is usually a long-term problem, the solution of which requires an investment in long-term research activities. The research reported here utilized fundamental and applied methods to learn about the behavior of pesticides in soil and water. Emphasis was on widely used chemicals or ones having been detected in groundwater. Studies on atrazine, for example, yield information that can be used for extrapolation to the behavior of related pesticides such as other triazines.

Details of work group actions are given in this comprehensive report containing program evaluation and progress information, and recommendations of research needs that may require special attention to obtain acceptable proposals. Also, certain problem areas are recommended for increased emphasis to reflect the impact of research already underway.

**INFORMATION CONTAINED IN THIS REPORT IS CONSIDERED PRELIMINARY AND THE PRINCIPAL INVESTIGATORS SHOULD BE CONTACTED FOR DETAILS AS TO INTERPRETATION AND USE.**

**Ready for technology transfer--**Those items designated with an **asterisk(*)** are considered ready for use and/or for adaptive research and demonstration, when results are compared among locations.

## CHEMICAL FATE and TRANSPORT

Of the USDA Program Objectives given earlier, those addressed by the Chemical Fate and Transport RPA projects are as follows:

USDA Research Plan for Water Quality, 1989--Objectives 1 and 2.

USDA Water Quality Initiative, 1991 Work Plan--Objective 1.

## Assessment

### State of Current Research

Research quality is good to excellent and is relevant to the above objectives. Emphasis is on fundamental research and over somewhat small scales of space and time. There is a need for identification of component research as part of the larger picture. Some general conclusions are:

**Sorption rates and relative mobility** are reasonably predicted given soil and pesticide properties. However, extrapolation from laboratory derived values to field applications can be difficult, and perhaps meaningless in soils having strong or well defined structure and macropores.

**Preferential flow is widespread** in many soils and is a major factor in the movement of chemicals to groundwater. This faster movement along pores, cracks, or channels in soils is of more concern when considering pesticides than for nutrients.

***Timing of pesticide contact with soil** as related to enough water to produce flow and method of application are very important concerning transport through and degradation in the root zone. Current results indicate a delay in irrigation or rain after application of pesticides can reduce movement.

**Frost and winter conditions** are related to some of the highest concentrations of nitrate and flow rate from the subsurface.

**Nitrogen and nutrient transfer** generally should be characterized and studied separately from pesticides. This is because they are an integral part of the soil-water system supplying nutrients to plants. Also, the very low concentrations of pesticides of concern tend to be more dependent on the ratio of transport rate to degradation rate.

### Research Opportunities and Needs

The working group believed the following to be high priority research needs.

**Predictability of preferential flow** in unstudied soils and substrata, such as on the basis of soil maps and surface surveys is very important for accurate technology. It is not practical to do site-specific studies for all possible soil conditions.

**A comprehensive treatment of preferential flow in flow models** is a general need. Some research is occurring.

**Techniques and tests for scaling up** from point samples to larger units, such as fields and landscapes.

**Sampling strategies considering spatial and temporal variability**, particularly as related to area and volumetric scale.

**More direct evidence of transferability** of results over space and time as well as chemicals and soils.

**Increased emphasis on high recharge areas** such as gravelly or sandy soils and permeable substratum.

**Source of pollutants** such as identifying whether pesticides are from a quasi-point or a non-point source.

**New and improved tools and techniques for:**

- **Vadose zone studies**, particularly from one meter depth to the permanent water table.
- **Schemes for spatial integration.**

### Changes in Program Operation

Scoring sheet for CSRS research proposal evaluation:

- Emphasize "relevance" category, such as an increase from 20 to 30 points. The relevance statements should have more credit for specific projects than for generic.
- De-emphasize scoring for "Scientific Base and Methodology" such as from 40 to 30 points. Particularly emphasize procedures in this category.

## Recommendations

Specific research needs and suggested changes in program operation are given in the above sections. General recommendations are as follows:

There is an overall need for integration of pieces, that is, information from Components research into management units.

Concurrently, fundamental knowledge and sound science must provide the basis for this improved agricultural chemical management.

There is often a conflict between long-term effects and short-term projects, a problem needing solution.

- Desires of managers and those who fund research are often shorter term than the processes needing study.
- This creates a problem in that longer term research must be done on problems of slow but persistent chemical change and transport, and on the reflection of management changes that often requires several years.

## Work Group Participants

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## TRANSFORMATION and REMEDIATION
## Pesticides, Other Organics and Microbes.

Research funded under this general RPA of the water quality program addresses the USDA Program Objectives, as follows:

USDA Research Plan for Water Quality, 1989--Objectives 1, 2 and 4.

USDA Water Quality Initiative 1991 Work Plan--Objective 1.

### Assessment

It must be emphasized that **movement and degradation of some pesticides is a long-term problem, the solution of which requires an investment in long-term research activities.** In an attempt, however, to produce short term results, FY 1989 awards were for 2 years and FY 1990 were for 2 or 3 years. The research has emphasized chemicals that are in wide use or are groundwater contaminants. For example, in numerous projects, scientists are studying atrazine fate and transport in soils. Studies of problem chemicals, such as atrazine, not only yield information on an important existing groundwater contaminant but also provide data that can be used for extrapolation to the behavior of related pesticides, such as other triazines.

### State of Current Research

The CSRS Special Grants and ARS programs have funded excellent research at a number of Land Grant Universities and ARS laboratories. The principal investigators are qualified to conduct the research and the overall quality of research is high. They are utilizing both basic and applied methods to evaluate behavior of pesticides in soil and water. The program is funding projects addressing a broad range of problems, from both a subject matter and geographic viewpoint. The investigators are using "cutting edge" analytical and experimental methods in conducting research.

The Group discussed accomplishments in several types of research areas, while recognizing that in certain examples other regions are making good progress as well. Numerous projects have made advances that can have an immediate impact on enhancing groundwater quality.

*__Treatment of wastes__--Methods have been developed, evaluated, and perfected for onfarm use that degrade potentially toxic pesticide wastes to non-toxic byproducts. These methods involve chemical or chemical plus microbial processes. Emphasis has been placed on atrazine, but the basic technology has been shown to be successful on several other pesticides. The technology can be transferred to users in the near future (CT, MD, NY, WI).

*__Baits__--Baits amended with an insecticide have been developed for control of corn rootworm larvae. This technology results in effective control of the pest and a 98% reduction in insecticide use. Baits can be used to monitor development of pest populations to guide scheduling of pesticide application. Commercialization of this technology is in the near future (SD).

*__Analytical methods__--Improved, more economical methods for extraction and analysis of pesticides have been developed. These will allow more cost-effective research and monitoring efforts. In the near future, it is possible that the cost for pesticide analysis in water samples could be reduced from the current \$80 to \$400 per sample to \$10 to \$15 per sample (MN, IA).

**Starch encapsulation**--Technology has been developed for successfully encapsulating pesticides. This results in reduced leaching, reduced application rates, improved management options, easier handling and comparable cost. This approach may be implemented with more adaptive research and industrial support (IN, MD, PA).

**Remediation**--Rapid decomposition of pesticide in pure systems has been demonstrated, but limited success has been shown in complex natural systems. Microbial cleanup of pesticide contaminated soils, such as spill sites, is difficult due to our imperfect understanding of basic chemistry and microbiology of the contaminated soils (PA).

**Microbial processes**--Enhanced degradation of pesticides in the rhizosphere (soil adjacent to plant roots) has been demonstrated. These results show the importance of the interaction of microbes, roots, and soil on the fate of pesticides in soil systems. The results have implications for management options such as timing and method of pesticide application to soils (MO, IN).

Research Opportunities and Needs

Current research needs were discussed along with implications of policy decisions on future activities. It was noted that possible policy decisions such as banning a specific pesticide should not negate ongoing research if, in existing projects, researchers are collecting fundamental information on processes affecting pesticide fate in soils and water. Specific research needs identified by the Work Group were the following:

**Basic research in abiotic and biotic methods**--For remediation of sites contaminated with pesticides.

**Structure/function relationships to predict fate of pesticides**--Information is needed to predict the sorption, decomposition, and fate of new compounds using structural data only.

**Coupling macropore flow and pesticide transformations**--Relatively rapid movement of a pesticide through pores in soils and substratum will likely alter the kinetics of chemical and microbial processes and thus pesticide fate.

**Persistence of pesticides**--Their fate in aquifers, substratum and soils as affected by nitrate. Designing management systems that reduce nitrate leaching may have a positive impact on negating a pesticide problem in groundwater, since it has been shown that nitrate inhibits the decomposition of atrazine in groundwater.

**Pesticides in forest systems**--Fate and transport under different plant and soil conditions than cropland.

**Adaptability range for rapid, economical analytical methods--**The ability to precisely monitor parent pesticide compounds and decomposition products should be increased over a broader spatial scale.

**Develop baits for a wider range of insect pests** to reduce effective amounts of insecticides.

**Starch encapsulation research should be expanded** to include additional soils and pesticides or other potential contaminants.

**Microbial population dynamics** in soils should be determined, including potential detrimental effects as influenced by.chemicals used in soil and crop management.

**Develop closed-loop systems for mixing and loading procedures** in the use of pesticides. Reuse of rinsates and reducing volume of rinsate should be emphasized in research to reduce important sources of contaminants.

Changes in Program Operation

Clarify RFP requirements pertaining to the importance of elucidating surface water linkage with groundwater quality. In many areas, for example, domestic water supplies are obtained from alluvial aquifers recharged by surface waters vulnerable to agrichemical contamination.

The Group expressed support for increased effort to obtain more sound proposals in sociologic and economic studies. Because the Social Sciences work group treated the topic in depth, this group deferred to their analysis and recommendations.

Maintain investigator driven approach to ensure top research productivity. Continue to have good science be the deciding factor in selection of fundable proposals.

A process is encouraged that optimizes the value of proposal reviewers' comments and that maximizes the percentage return to authors. These comments should be as useful as possible to authors to improve future proposals.

## Recommendations

Specific research needs given above are included as recommendations. Further emphasis is given to some current developments of research that appear to merit special attention.

Reduced pesticide usage for corn rootworm control, and less contamination impact have been found when using baits and encapsulated herbicides in starch granules. Increased adaptive research is needed for a variety of soil, crop and climate conditions before widespread use will occur.

Oxidative chemical methods with good potential to remediate pesticide wastes are being developed.
- Increase adaptive research to further clarify conditions for use.

Many "applications" are being used today with limited success because underlying fundamental principles affecting the relevant processes are unknown.

Research on basic processes of remediating contaminated soils and water must continue. Understanding chemical-soils interactions will also greatly benefit nonagricultural problems such as superfund site cleanup.

Continue research on widely used pesticides even if they may lose label approval. Many already contaminated sites, or ones that may be in the future, will likely require remediation, and an understanding of basic processes will apply to related chemicals.

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## NITROGEN other NUTRIENTS, WASTES, METALS

Research funded under this general RPA of the water quality program addresses the USDA Program Objectives, as follows:

USDA Research Plan for Water Quality, 1989--Objectives 1, 3, 5 and 6.

USDA Water Quality Initiative 1991 Work Plan--Objectives 1 and 3.

The objective of the water quality initiative most relevant to this working group is, "Develop and induce the adoption of technically and economically effective agrichemical management and agricultural production strategies to protect water quality." More specifically, this work group adopted several aspects of the objectives that relate to water quality as the standard for this evaluation, namely: The work group's approach was to evaluate the current research on water quality with respect to (1) sources of contamination, (2) avoidance techniques, (3) amelioration strategies, and (4) detection and diagnosis procedures. Most of the research activities fit into these categories. They relate to needed information under objectives given above.

### Assessment

The abstracts and research reports generally indicate that the research underway is of excellent quality. And, it is not only well-focused on the objectives of the individual projects but it targets the broader objectives of the water quality research program. The poster papers presented at this workshop substantiate that impression. Some research approaches are similar, and justifiably so, because of the large area and wide range of soil, crop and climate conditions covered by these two regions.

With regard to contaminants, the focus of research strongly emphasizes nitrate nitrogen. Emphasis on nitrate is justifiable because of: (1) Its importance as a potential health hazard in drinking water, (2) its high mobility in soil and geologic material, (3) its omnipresence in the biosphere, and (4) its vital importance to agricultural production. There are, however, other potential contaminants discussed later that need attention.

### State of Current Research

**Sources of high N**--projects include poultry and dairy manures, fertilizers, and legumes.

**Avoidance techniques**--projects are mostly concerned with N use-efficiency to reduce nitrate buildup in soils. Projects involve amount, timing, and placement of N fertilizers and alternative sources in the forms of animal manures, wastes, and legumes.

**Amelioration strategies** that are being researched are scavenging, N immobilization, denitrification, and plant uptake of residual or excess nitrate.

- Scavenger crops are mainly cover crops, small grains, soybean, or deep-rooted crops (primarily alfalfa) used in crop rotations.
- N immobilization converts nitrate to an organic compound and occurs in the presence of a carbon source in the soil. Currently, that work mostly centers on the use of animal manure but should be expanded to other carbon sources.
- Denitrification of nitrate, to a non contaminant state below the normal rooting zone of crops, is being studied for the prospect of enhancing and capitalizing on this process to reduce nitrate concentrations.
- Interception of excess residual nitrate by crop roots before it exits the root zone to remove it from the soil by harvesting the crop, or to recycle the nitrate to shallower soil depths, is emphasized in some research.

**Detection and diagnostic procedures for N sufficiency** have been substantially improved by the development and evaluation of the pre-sidedress soil nitrate test (PSNT), and a rapid plant tissue test and a chlorophyll test.

- Both the soil and tissue tests have the potential to permit timely supplemental applications of N fertilizer to remediate yield-limiting deficiencies while avoiding excessive nitrate.
- The PSNT is a useful tool for assessing nitrate sufficiency of the soil at a critical time in the growth stage of corn, when the need for N is beginning to increase rapidly.(VT) Interest in PSNT has developed in many other areas.(MD, PA, DE, WI, IA, MN)
- A rapid plant tissue and chlorophyll test has been successfully correlated with corn yields and is being evaluated in other areas.(NE)

**Note**: Soil testing for residual nitrate to depths of 2 to 4 ft has been a widely used practice for N fertilizer recommendations in rainfall-limiting areas of the Great Plains, the Northwest, the Rocky Mountain States, and certain other areas for 20 to 35 years. This provides a background of valuable information and experience on which to build a successful program in the humid areas of the country.

**A successful N-management system without excess N** will likely involve using a combination of several measurements of N compounds, cropping history, N needs at different periods of plant growth, weather records, and precipitation forecasts with probabilities. The N system is complicated and will require much well-coordinated analysis of existing research information, and well planned complementary research

**The Work Group recommended a "white paper"** should be prepared on how much nitrate is required in the root zones of crops for satisfactory yields, and how much can be expected to leach out of the root zones of various crops when best management practices are used. **Note**: A special workshop for this purpose is planned for December, 1991. Information from previous research on nitrate, supplemented by results from currently funded studies, can answer many important water quality questions.

They also suggested that targeted workshops involving representatives of EPA, USGS, USDA, Cooperative Extension Service (CES) and SAES would be useful to highlight applicable accomplishments of the water quality research initiative and supporting information from other research sources. Particular emphasis should be on information to support education and technology transfer for successful voluntary water quality efforts by agriculturalists.

Research Opportunities and Needs

**Information on timing of N transformations to nitrate** is needed from largely organic or alternative sources, for different soils, and under various soil, crop, and water management. These sources include animal manures, sewage sludges, composted wastes, and legumes.
- This knowledge is crucial to successful use of alternative N sources in cropping systems, and is critical for effective N management to help avoid nitrate contamination of groundwater.
- The amount of nitrate credit to recommend from these N sources, for farmers to use in their soil fertility programs, must be more accurately determined.

**Conservation tillage can improve or worsen nitrate leaching**--Identifying soil, water, and crop management conditions under which nitrate leaching to groundwater can be controlled within acceptable levels is a critical need in the water quality program.
- Different types of conservation tillage have produced conflicting results on nitrate leaching.
- A point was made that SCS widely recommends that farmers use conservation tillage to comply with soil erosion limits.

**Rural septic systems and turfgrass areas** are important potential sources of groundwater contaminants including, primarily, nitrate and runoff of pesticides, respectively.
- Better definition of contributions of these sources to groundwater contamination is a high priority.
- These problem areas have been eligible in the RFP for CSRS Special Grants under "rural residences and rural communities", but competitive proposals have not been adequate.

**Projects that include a technology transfer** component should be encouraged to minimize delay for new information to be used by education and technical action agencies, since an effective agricultural water quality program must be implemented by farmers.

- If farming practices are to be changed in response to information developed by research on water quality problems, what changes will be necessary or result in agricultural infrastructure and socioeconomic aspects of farming?

**Precision evaluation/application of nutrients**--Accurate determination of nutrient needs and application for economic crop production can reduce or eliminate excesses that could cause excessive concentrations in soils and water. Innovative techniques and strategies, different technologies, and emerging issue-oriented problems present many opportunities for complementary water quality research projects. Based on results of research funded by the Initiative and other sources, and prior knowledge of nutrients in soils, the working group identified the following avoidance strategies that appear to hold considerable promise in the near future to significantly reduce nutrient movement beyond the root zone of plants.

- Soil tests for nitrogen--Proven methods complemented by innovative tests, and coordination of tests and recommendations among states.
- Quick field tests for N sufficiency--Chemical and chlorophyll tests of plant tissues that can be used to determine N sufficiency of crops.
- Fertilizer application equipment--Computerized, continuous N-status detection in plants or soils, coupled with adjustable fertilizer application rate capability.
- Remote sensing as a detection tool--The chlorophyll test has excellent adaptability to this proven technology.
- Application of nutrients according to soil and landscape properties and maps--"Farming by soils" is an emerging technology, already being used in some areas, that promises to be beneficial to water quality through precision fertilizer application to match needs of soils and crops and avoid excesses.

At this time, the Work Group placed a lower priority for research on other nutrients and metals as potential groundwater contaminants from agricultural land. However, the group expressed a concern about the potential for pathogenic microorganisms as contaminants in agriculture.

## Recommendations

The Work Group urged priority for research needs given in Research Needs and Opportunities, and consider the following as needed collaborative research with scientists of other disciplines.

Pathogenic microorganisms from animal manure or sewage sludge as potential groundwater contaminants from agricultural land.

Relationships between water quality problems and energy requirements, especially with regard to the real cost of fossil fuels used in N manufacture and for farming operations that may be affected by technology changes.

The effects of changing practices in response to water quality initiatives, on the agricultural infrastructure and socioeconomic aspects of farming is a high priority.

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## PRODUCTION MANAGEMENT SYSTEMS

Research funded under this general RPA of the water quality program addresses the USDA Program Objectives, as follows:

USDA Research Plan for Water Quality, 1989--Objectives 1, 3, 5 and 6.

USDA Water Quality Initiative 1991 Work Plan--Objectives 2 and 3.

### Assessment

The working group on Production Management Systems had difficulty in defining the boundaries of a system and how to order the various subsystems to facilitate constructive discussion. An approach was proposed giving the categories in two groups.

A. **Land Use Management**--Enterprise or Landscape Level

| | |
|---|---|
| Soil Management | Pest Management |
| Crop Management | Weeds |
| Water Management | Insects |
| Fertility Management | Disease |
| Farmstead Management | |

B. **Decision support systems**

| | |
|---|---|
| Climate | Slope |
| Location in watershed or aquifer | Soil properties |
| Aquifer depth | Farm programs |

### State of Current Research

The research in this RPA overlaps with projects initiated within the Midwest Initiative, which are oriented to large scale or area studies. Geographic Areas Systems research embodies comprehensive studies for evaluation of management systems and their water quality impacts. Five MSEA are underway and are treated in detail as PART II. A number of field and watershed scale management projects have been developed or re-focused to address specific management issues or practices within the MSEA concept, or to expand application of specific site findings to other areas

within the regions. This water quality effort is a prime example of cooperation and collaboration in research among states and agencies. The research initiated relates directly to the objectives cited above.

Priority Components research in the Production Management Systems RPA generally relates to systems of smaller scale, or to subsystems. Many of the projects are receiving new funding associated with the Initiative, which very effectively augments base program funding for water quality research by allowing the studies to be more comprehensive an obtain answers quicker. Some of these studies are as follows:

**Soil, crop, and chemical management practices** such as ridge tillage, irrigation management to reduce chemical flux below the root zone, water table management, reduction of chemical use, and others.

**Decision aid systems and model**--Development and application research is underway. These activities encompass biological models of weed emergence and population dynamics, physically based transport and fate models, integrated biological and physical models, and application of models with geographic information systems (GIS) for spatial vulnerability assessment.

**Decision aid systems support** includes development of large data and information bases, incorporation of fate and transport models, and development of decision criteria.

**Methodologies for risk assessment** are being addressed, particularly climate effects and timing of operations.

Research Opportunities and Needs

Although research is ongoing and new funding has been added in some of the following problem areas, deficiencies of information and need for enhancement were identified as high priority needs for adequate success in systems development and evaluation.

Point source identification and control.
Critical area identification and use.
Prescription farming and required sensors, controllers, etc.
Spatial relationships: soil associations, fields, aquifers.
Landscape relationships.

Effective nitrogen soil tests and tissue tests.
Community-scale management of manure and other wastes.
Tillage impacts on nitrate--ridge, conservation, no-till.
Irrigation scheduling as related to soil vulnerability.
Decision-aid systems and appropriate data bases.

Pest assessment technologies.
Risk analysis, particularly as associated with weather variables.
Quantitative integration of biological, physical and economic models.
How to factor in toxicity levels of chemicals.

Crop rotation effects--short- and long-term.
Buffer strips and wetlands.
Erosion and water quality.
Water resource protection--surface and subsurface water, water interrelationships.

Although this is an imposing list, several topics are being, or could be, covered in the same research projects. Also, some of the topics are listed by the other work groups, which in effect shortens the list.

**Significant opportunities in water quality research** were identified by the work group, and scientists are encouraged to include them as parts of proposals.

**Integration of applicable biological, physical, and economic models.**

**Decision support systems** for evaluation of production systems and economic and environment risk assessments.
**Enhancement and coordination of data bases and models** across regions for their development and use.
**Expansion of models and GIS-based methods for vulnerability assessment**, including landscape and other spatial interactions, and critical sources of contaminants.
**Off-field or off-site effects and remediation**--Buffer strips, wetlands, other landscape modifications.
**Pest infestation critical levels** for reduction in chemical use.
**Development of methods to enhance soils data** and other physical descriptions required in models.

Changes in Research Programs

In addition to the above, the need for new and continued strong support for field- and farm-scale research on production systems was recognized. Research must be expanded to larger scales of size to address urgent needs of regulatory agencies and resource management agencies, such as SCS, in developing and evaluating watershed and aquifer-wide management strategies.

## Recommendations

RFP and other research management protocols should recognize the above Research Opportunities and Needs to expand research scale.

A formal mechanism to coordinate model testing and application should be instituted.
Involvement of SCS, ES and other management agencies should be encouraged in research planning and conduct.
A systems approach or its mechanism should be instituted to synthesize, interpret, extrapolate and publicize findings, from all water quality research projects, to a wide audience including users of information, policy makers and political bodies.

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1 J. L Baker, Chair of working group
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3 R. A. Leonard, Evaluation Panel member

## SOCIAL SCIENCES[1]

### Introduction

Economics, and other social science research information is needed for decisions at various levels. Potential farm management adjustments must be evaluated from the technical and economic standpoint to determine the effects on net revenue of different approaches to managing chemicals. Economic and sociologic analyses are necessary to determine if adjustments on the part of farmers can be brought about on a voluntarily basis, or if incentives must be employed.

Beyond the farm level, it is essential to understand the implications of regulatory actions on local and regional economies, and on net national benefits attributable to farm production as well as to chemical control actions. Measurement of these effects through input/output analysis, econometric regional models, or other modeling techniques is a necessary component of policy analysis. Both market and non-market effects must be included. Methodological advances in the measurement of benefits and costs must be a part of this research. Off-farm effects (externalities) are also essential.

In addition, it is necessary to plan for the time when the social sciences will be asked to evaluate the effectiveness of the entire CSRS, ARS, and Government-wide Water Quality Research Program. This will require a base of social science information at the farm, state, regional and national levels, and cannot be accomplished through a short term "brush-fire" study.

Social Sciences Work Group participants agreed that information needed for evaluation of policy alternatives relative to goals and objectives of the Water Quality Research Program clearly includes input from social sciences. Failure to integrate economics and other social science research into the Program will result in lack of information for policy guidance regarding industry response to, and economic and social implications of, regulatory or other actions designed to accomplish Program objectives. Policy decisions made without appropriate social science information will result in less successful and/or more costly chemical control adjustments.

The following goals and objectives of the water quality program require social science research to obtain the necessary information.

Goal 2. To develop new and improved agricultural systems that are cost effective and enhance groundwater quality.

Research funded under this general RPA of the water quality program addresses the USDA Program Objectives, as follows:

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1 V. J. Norton, West Virginia Univ., Evaluation Panel member and Workshop Chair
O. H. Buller, Kansas State University, Recorder
Fifteen to 20 scientists and administrators participated.

USDA Research Plan for Water Quality, 1989--Objectives 3, 4, 5 and 6.

USDA Water Quality Initiative 1991 Work Plan--Objective 3.

Clearly, Goal 2, and Objectives 3,5 and 6 of the 1989 Plan, and Objective3 ot the 1991 Work Plan require substantial research input from social sciences such as economics, sociology, and political science.

## Assessment

### Status of Current Research

The current economics, sociology and other social science research related to water quality is not adequate to provide the information needed for farm, state, regional and national level decisions. The grants program could supplement this deficiency. However, the few projects now underway that are supported by the water quality Initiative are too limited in scope and/or depth to answer the complex and varied questions that must be addressed through social science research. Although the number of social sciences-type proposals in the grants program has increased over a 3-year period, it still remains too low.

The limited involvement of researchers in social sciences in the CSRS Water Quality Research Program is not the lack of challenging research topics. Rather, for some reason it has been the lack of adequate economics, sociology, and other social sciences proposals. The key, therefore, is to expand the number of high quality proposals from social scientists. The following research needs and suggested strategies are given with the intent to stimulate development of significant involvement of researchers in the Social Sciences.

### Research Opportunities and Needs

**Scientific research results must be aggregated** beyond plot and field scales for them to be useful in policy analysis.
**Predictive models that allow integration** of social science research results need to be formulated. The key in policy research is to develop predictions.
**The range in which parameter estimates are valid** within the predictive models must be known.
**Risk and stochastic elements** of the problems must be considered.

Although social scientists need not be involved in all of the research, the process should be in place for a role in formulating research questions oriented toward identifying:

**The incentives necessary to encourage farmers** to undertake chemical use adjustments.
**Benefits, costs, and economic impacts** at all levels of alternative actions--the benefits should include both market and non-market, and costs should include internal and external effects.

### Changes in Program

The Workshop participants felt it would be most productive to concentrate on a recommended strategy to develop the desired research, including some special efforts and actions on the part of CSRS and others. It should be recognized that each of the social science disciplines is based on an unique set of concepts and principals which, in turn, makes the potential contribution of each unique and not properly characterized by any single term such as socioeconomic. This term may cause an impression of being one discipline. It follows from this, therefore, that a proposal having a sociologist and an economist should be considered as multidiscliplinary in the proposal review process.

The RFP should be clear that social science projects, provided they are relevant to the goals and objectives and are of high quality, will be among the high priority areas to be funded during the next review period. The latter will provide extra incentive to draw more social science researchers into the proposal process of the CSRS water quality program. This will help to assure that the best and most qualified economists, sociologists and other social scientists will take the time to prepare proposals.

**Policy analysis should be emphasized** clearly in one section of the RFP, though it has been an eligible problem in past RPA.

Proposal review panelists and proposals should be grouped so that more than one social scientist is on each panel. This will help to assure appropriate review of social science proposals, generate a set of individuals that are more likely to promote submitting proposals in the future, and instill confidence in the process among social science researchers.

### Recommendations

Research opportunities and needs in problem areas involving the Social Sciences are given above and are not repeated here. The Group expressed confidence that the additional suggestions listed below will bring about a greater number of quality proposals. The participants also agreed that any one, or sub-set, of the suggested actions would not be adequate, as it was considered the minimum that program administrators should do to be successful in this regard.

An information plan should be designed to broaden the base of interested and qualified social scientists. This should be formulated and carried out by the individual(s) specified in "3" above. It should be designed to spark the interest of the following groups that have basically ignored the Program RFPs.

- Traditional agricultural economists, such as farm management, production and marketing specialists. The expertise of these individuals is needed for the farm level analyses.
- Traditional policy analysts who deal with all aspects of federal agricultural policy. Their policy experience could contribute greatly to policy aspects of the Program objectives.
- Resource and environmental economists who are doing excellent research in water quality for EPA, Department of Interior, NOAA, and other government agencies. Few of these appear to have been drawn into the CSRS water quality research areas even though the issues are the same non-market benefits, externalities, and questions of willingness-to-pay and willingness-to-accept. All of these are absolutely needed to accomplish the water quality Program objectives.
- Rural sociologists and others who have been working in traditional farm and rural community development.

Establish in CSRS, for at least a year or two, social science leadership with sound experience in areas of investigation relevant to water quality research. For the water quality problem areas that must involve researchers from the Social Sciences, stimulate a professional relationship between universities and CSRS similar to that existing among CSRS and ARS of USDA and physical and biological scientists in universities. To produce this effect, place a qualified individual in CSRS using a CSRS-university IPA agreement, or by a temporary transfer from ERS, EPA, or other government agency, if available.

## TECHNOLOGY TRANSFER[1]

Technology Transfer was one of the cross-cutting committees established at the Water Quality Progress/Evaluation meeting. The charge given to this committee was to look at needs, concerns and recommendations for improving technology transfer over all technical areas or RPA in the component research programs within the President's Water Quality Initiative. A summary of the observations and suggestions made by the committee is presented in the remainder of this section.

## Scope and Definition

**Technology transfer should be broadly defined** to include extension, information and education, outreach, public service and public relations.

- The opinions of participants varied widely as to the effectiveness of present technology transfer efforts. Some felt nearly all relevant technology was being effectively transferred, while others stated that little was being done. Part of the disagreement was due to a difference in understanding what technology transfer includes.

**The "users" of the research information** include a wide range of clients.

- In addition to farmers and other agricultural producers, clients include agribusiness, governmental agencies, elected officials, special interest groups and the general public.

**Technology transfer with agricultural producers and agribusiness** representatives is rather well established for applied research projects.

- Inadequate contacts, however, are being made with the researchers and governmental agencies, elected officials and those from environmental special interest groups who influence public policy.

**A continuum exists in terms of scientific inquiry** ranging from fundamental or basic research at one end of the spectrum, through applied and adaptive research, and on to demonstration or observational trials at the other end.

- Technology transfer is most critical in the midpoint region, and strong linkages with Extension and SCS are needed in this range of applied studies.

## Recommendations

Involve Extension and SCS early in the research planning process, especially on the applied projects where an early transfer of results may be needed.

- If these education and "action" agencies are involved early and become a partner in the studies, technology transfer efforts are usually much more effective.

Some administrative changes should be considered which would help strengthen efforts to have a more effective technology transfer program.

- Giving points in the evaluation scoresheet for involvement of Extension and SCS--There was not much support for this suggestion. It was felt that many of the fundamental projects do not need a technology transfer component, and it was observed that "forced" collaboration usually will not improve technology transfer.

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[1] L. M. Walsh, Chair and Panel Member, SAES/CES, University of Wisconsin, Madison, WI
H. Hilner, Co-Chair, SCS, Lansing, MI
G. D. Bubenzer, Recorder, SAES, University of Wisconsin, Madison
There were 25 to 30 participants in this work group.

Developing a separate subsection within each RPA to specifically address technology transfer needs;

- This suggestion may have some merit in terms of focusing technology transfer efforts, but it needs to be an "add-on" in terms of funding. Many individual projects would still be more effective with a technology transfer component.

Reserving "off-the-top" funds to permit the addition of a funded technology transfer component to appropriate projects.

- Proposals would be developed to reflect collaboration, with awards made on a competitive basis. This process would ensure a viable technology transfer component for those projects where the need was the greatest.
- The pool of funds to support such an effort should come from CSRS and Extension on a 50:50 match basis. Both research and extension stand to gain from an improved technology transfer program, so both should support efforts to enhance the effectiveness of these programs to improve water quality.
- An increase above the established dollar limits for individual and multi institution awards would be appropriate.

Reserve "off-the-top" funds for technology transfer specialist(s) in CSRS and ARS.

- This suggestion has some merit because "users" in the governmental and political arena would be better served; however, it would appear to duplicate USDA Extension Service responsibilities. Again, this would require an "add-on" to the budget because most individual applied projects would still need a technology transfer component.
- Tying together certain component research projects with the demonstration and hydrologic unit programs sponsored by Extension and SCS.

Clearly, more effort needs to be made to bring some of these programs together. They would complement one another, especially in terms of gathering baseline information and building data bases. And, of course, such collaboration would enhance--virtually ensure--efforts to effectively incorporate research findings into all outreach programs.

## Summary

Technology transfer is a very important part of the Priority Components research program. Even though the outreach efforts have been adequate for some projects, more emphasis needs to be placed on technology transfer, especially for the applied projects. Furthermore, special efforts should be made to improve the transfer of research results to users in the governmental and public section as well as agricultural producers.

The long-term effectiveness and viability of this type of research program will be greatly influenced by our success or failure in transferring research information to a broad range of users. In fact, given the importance of technology transfer, the committee recommends that CSRS and ARS find ways to enhance the incentives for improving technology transfer within each project as well as giving this activity more attention administratively with their offices.

## COMMENTS

The Review and Evaluation Panel complimented the participants on their cooperation in the evaluation process and the excellent posters which displayed progress of their research, and served as the basis for constructive discussions. The scientists working in PART I, Components Research, welcomed the opportunity to present preliminary results, gain from the interaction with other researchers, and critique the work displayed by their peers. Benefits from the exchange of ideas, recognition of trends in research results, and the realization that they and users of information are a part of the evaluation and planning process, were among the positive comments.

## REVIEW and EVALUATION PANEL

The members of the Review and Evaluation Panel are identified in the following table. Those assisting with operations of the work groups are listed in the respective footnotes at the end of the discussion for each research problem area.

| Panelist | Title, Affiliation, (Expertise) | Panel Responsibility |
|---|---|---|
| W. W. Frye | Professor, University of Kentucky (Soil Fertility, plant nutrition, mgt) | N, other Nutrients, Wastes, Metals |
| R. A. Leonard | Supv Soil Sci, ARS/USDA, Tifton, GA (Groundwater Chem, Systems/Models) | Production Management Systems |
| V. J. Norton | Professor, Head, Div Resource Mgt West VA Univ, (Resource Economics) | Social Sciences |
| L. E. Sommers | Professor, Head, Agron, CO State Univ (Microbiolgy, Biochemistry) | Transformation and Remediation-Pesticides and other Organics |
| A. W. Warrick | Professor, University of Arizona (Physics, preferential flow, models) | Chemical Fate and Transport |
| L. M. Walsh | Professor, University of Wisconsin (Soil Fertility, mgt, Research/Ext) | Technology Transfer |
| C. M. Smith | Visiting Professor, Penn State Univ | Panel Chairman |

# PART II. SELECTED GEOGRAPHIC SYSTEMS
# Management Systems Evaluation Areas (MSEA)

## INTRODUCTION

The U.S. Department of Agriculture (USDA) collaborating with State Agricultural Experiment Stations (SAES) initiated a long-term Midwest Initiative on Water Quality in 1990 as a part of the President's Water Quality Initiative. The program is administered by the Agricultural Research Service (ARS) and the Cooperative State Research Service (CSRS) in cooperation with SAES, the U.S. Geological Survey (USGS) and the U.S. Environmental Protection Agency (EPA). Interagency coordination is achieved through the USDA Working Group on Water Quality's Committee on Research and Development. The USDA Midwest Initiative on Water Quality has been merged with part of the USGS Midcontinent Herbicide Initiative and the EPA Midwest Agrichemical Surface/Subsurface Transport and Effects Research (MASTER) program which will begin in fiscal year 1992.

Through a competitive merit review process, five Management System Evaluation Areas (MSEA) were selected to represent certain predetermined soil, crop management, geologic, and climatic characteristics and conditions of the Midwest Cornbelt. During 1990, researchers in Iowa, Minnesota (with satellite sites in North Dakota, South Dakota, and Wisconsin), Missouri, Nebraska, and Ohio developed detailed work plans for 10 research sites including agronomic and hydrogeologic characteristics. Principal Investigators developed consensus methods and approaches and began field experiments in 1991.

## STATE of MSEA PROGRAM

The current MSEA program resulted from merging the USDA plan described above with USGS's Midcontinent Herbicide Initiative. Other Federal agencies, especially EPA, as well as States and universities, also have contributed to the research design. The five projects selected for the MSEA program now form part of the larger Midwest Initiative on Water Quality with a research agenda that has been organized to address 6 research objectives.

The goal of MSEA research is to define and evaluate agricultural management systems that protect water quality for a geographical area. Specific objectives of the MSEA research are to:

1. Measure the impact of farming systems on chemical constituents of ground and surface water.
2. Identify and increase the understanding of processes that control fate and transport of agricultural chemicals.
3. Assess the impact of agricultural chemicals and production practices on ecosystems associated with agriculture.
4. Identify and develop management systems that protect water and ecological resources.
5. Evaluate the social and economic impacts of management systems.
6. Transfer appropriate technology for use on the land.

The Request for Proposals (RFP), FY 1990 required that the MSEA: (1) represent a significant (over 50%) corn and soybean production area; (2) overlie a significant ground water aquifer; (3) have a real or potential water quality problem as a result of agricultural production practices; (4) be currently affected by nonpoint contaminant sources that could be placed under management control by the project; (5) have a base potential reaction time for agricultural chemicals to move significantly or reach the aquifer that would allow definitive measurements within the time of the project; (6) have an annual water budget, including irrigation where applicable, to identify the sources, quantity, and timing of waters available for chemical transport; (7) be available to, or under the control of, the project directors for at least five years; and (8) be able to document the potential research, monitoring, and technology transfer issues, as determined through discussion with federal project administrators and private sources. Site selections were based on scientific merit, area or site attributes of the MSEA, and availability of resources.

The five MSEA projects were selected in a competitive process that stressed individual project excellence. Progress toward interagency coordination has been enhanced by the establishment of a regional agency MSEA Management Team and a MSEA Principal Investigators' Steering Committee. The Steering Committee has led to significant agreements on QA/QC, Database Management, Agricultural Practices and other project management issues. Two Steering Committee efforts, Socioeconomics and Modeling, lend themselves to development of regionwide generalization. Additional effort and resources beyond the current efforts of the MSEA projects are needed to develop further regional integration of research results.

Of the 6 objectives identified for the MSEA research, the review panel believes the overall program has the capability to attain objectives 1, 3, 5, and 6 in a short timeframe. Objectives 2 and 4 may take more time. Increasing the understanding of fate and transport processes and developing improved agricultural management systems that are environmentally and economically sound could require more than 5 years of MSEA research in the Midwest.

### Project Administration

The MSEA project is cooperatively administered by the participating agencies in concert with the Principal Investigators of the five sites through appropriate committees and subcommittees.

The overall President's Initiative on Enhancing Water Quality is presently under the broad oversight of the Research and Development Committee of the USDA Working Group on Water Quality, including representatives from USDA, USGS, and EPA. Oversight of the MSEA project is

guided by a MSEA Management Team consisting of representatives of participating agencies. A MSEA Steering Committee, composed of Principal Investigators from the five sites, contributes to the theoretical and technical infrastructure of the project and receives guidance and recommendations from the Management Team.

As the MSEA Program Plan nears completion, the Review Team recommends that the Research and Development Committee needs to play an increasing role by providing guidelines and timeframes from the national perspective. The Management Team needs to ensure that the 5 projects are producing the results specified and that they are properly managed to meet program objectives. The Steering Committee and Technical Subcommittees should move from a planning to an implementation mode.

## Technical Subcommittees

The Steering Committee is supported by seven technical subcommittees:

Management Systems Research. The cropping systems that are being evaluated by the MSEA projects were developed to address ground and surface water contamination problems specific to each area. Emphasis is properly placed on a reference cropping system that is widely used in the MSEA region. The review team believes that the limitations on the number of management systems and agricultural chemicals (nitrogen, atrazine, alachlor, and carbofuran) that can be evaluated because of site capabilities and available resources has resulted in possible omissions. At some of the areas, an additional management system that is not subject to these restrictions could be superimposed if additional funding were available or if the projects were extended beyond 1995.

Quality Assurance/Quality Control. The QA/QC subcommittee has the well-defined purpose of verifying project results and recommending remedial actions. The QA/QC subcommittee has effectively developed protocols and procedures for individual laboratories and an external evaluation of QA/QC results for the analysis of soil and water samples. Each MSEA is responsible for its own QA/QC protocols with respect to collection of soil and water samples. The review team suggests that the QA/QC Subcommittee needs to move forward with finalizing the QA/QC plan, implementing the plan for an external review laboratory, developing evaluation criteria, and comparing results among laboratories.

Decision Aids/Models. The MSEA projects will provide information from a range of geographic, hydrologic, and climatic conditions to extend the scale at which many models are currently used. The MSEA program will make available to individuals, agencies, and institutions consistent data and provide field laboratories to test, validate, and improve existing and new models. The subcommittee on decision aids/models has selected 4 water quality models for evaluation at most sites. The review team stresses that the comparisons of these models need to address the validation and verification of these models based on the core data in the regional MSEA databases.

Regional Data Management. The subcommittee on data management has completed the tasks of general data handling, general data transfer, and general data table structure. Each MSEA will house core data in a relational database. Specific procedures and approaches have not been developed for a regional data analysis and final regional data storage. The subcommittee has not addressed the question of the deficiencies that could occur in the database.

Socioeconomics. Each MSEA is collecting socioeconomic information which will be combined with various models to predict adoption of alternative management systems. The findings from the various socioeconomic surveys will have relevance. The socioeconomic subcommittee is encouraged by the review team to show how the various socioeconomic surveys will be integrated and coordinated to address water quality policy issues across the Midwest.

Technology Transfer. Each MSEA submitted a proposal to develop the educational component of the MSEA program. Each MSEA has hired an extension specialist and a regional extension coordinator, stationed in Iowa, has been hired. The regional extension coordinator has a major role for

coordination with other water quality projects and agencies across the entire Midwest. The review team commends the program on the excellent opportunities for training, demonstration, and technology transfer to farmers and the general public.

Ecologic Efforts. Concentrations of chemicals in water are not always precise indicators of an ecosystem's health. Ecosystem health in terms of fish and wildlife, eroded soils, and recreational benefits can still be impaired. The MASTER initiative is an EPA component of the MSEA program which addresses ecological effects. To meet the objectives of MSEA program, the review team suggests that the ecological effects research needs to be broadly based across the Midwest.

## Regional Review and Evaluation

Columbus, Ohio

### Introduction

The Research and Development Committee convened an overview meeting at Columbus, Ohio, on June 3 and 4, 1991, to review progress on project integration made by MSEA project administration and technical subcommittees. An additional aspect of the review was to develop an understanding of the complex administration of research activities and identify appropriate cross-site capability for documenting regional patterns. From June 5 to June 21, 1991, the 10 sites in 8 States actively involved in MSEA research also were reviewed by a team consisting of Research and Development Committee representatives and invited university specialists from outside the Midwest. These reviews emphasized the USDA-funded research. The principal purposes of the MSEA review and evaluations were:

- Evaluation and, if appropriate, recommend changes in the MSEA research plan and program.
- Identify research gaps.
- Identify interest in continuation and/or expansion of the MSEA program.
- Enhance communication on the MSEA program at all levels.
- Assure success of an interagency water quality program.

### Recommendations

MSEA Program Administration

1. The Research and Development Committee of the USDA Working Group on Water Quality needs to increase its role in providing guidance to the MSEA program.
2. The Management Team needs to stress coordination among the MSEA projects to obtain timely and widely applicable results.
3. The Steering Committee and technical subcommittees should continue to expand efforts towards initiation and completion of regional project objectives.
4. ARS, CSRS, USGS, and EPA should stress the importance of continued coordination and cooperation towards regionalization of the Midwest Initiative on Water Quality.

Overall MSEA Program

1. The MSEA projects should place more emphasis on understanding the processes that control fate and transport of agricultural chemicals below the crop root zone to improve predictions on vulnerable areas for water quality contamination.
2. Additional management systems to expand the number of agricultural chemical practices being tested could be initiated in the fourth year if funding for the MSEA projects were extended beyond 1995.
3. A set of major hypotheses needs to be clearly defined and agreed upon by all the MSEA sites. (They are nearly complete at the time of this report finalization.)
4. The QA/QC subcommittee needs to move quickly toward implementation of the QA/QC plan.

5. The decision aid/modeling subcommittee should proceed faster to develop procedures and protocols for the comparison of decision aids and models among all the MSEA sites.
6. The regional data management subcommittee should finalize procedures and approaches for development and implementation of regional databases, guidelines for data storage, data release and transmittal.
7. The socioeconomics subcommittee needs to consider developing a common or minimum question survey that addresses regional economic and environmental impacts across all the MSEA sites.
8. The regional extension coordinator is a key participant across all the MSEA projects in the educational and technology transfer activities resulting from the research, and should develop an action plan in coordination with research and action agencies.
9. EPA's MASTER program on ecologic effects needs to be coordinated with MSEA research across the Midwest, and a detailed plan to accomplish this should be developed.

## REGIONALIZATION of the MIDWEST INITIATIVE

There continues to be a strong effort to develop a coordinated and realistic approach for projecting the benefits of implementing improved farming systems beyond the MSEA research sites themselves in the Midwest.

### Recommendations

Recommendations of the Review Team are specific to the MSEA program and involve all the MSEA projects.

The Review Team suggested the MSEA research program should start from a single, synthesizing objective such as: Determine the applicability and adaptability of the MSEA and associated Priority Component research to specific areas or regions near each MSEA project using common procedures.

**The Water Quality Research and Development Committee** is encouraged to complete the following tasks over the next six months:

1. Identify a technical subcommittee from the four MSEA funding agencies to develop a regionalization work plan within the current MSEA objectives, a timeframe for completion, and an estimated budget.
2. Mesh other agencies into the MSEA regionalization work plan and integrate expertise and existing information wherever possible.
3. Develop a risk-based approach to assess the benefits of implementing modified farming systems on water quality in the Midwest.
4. Promote the regionalization effort through effective communication among all investigators in the MSEA program.

**Development of a regionalization work plan** should utilize the following suggestions:

1. Define a limited set of regional objectives that can be achieved within existing and developing knowledge and resources.
2. Integrate existing information collected at the MSEA sites; for example, use data sets to verify models that have high transfer potential.
3. Focus on agricultural practices to mitigate conditions that produce ground water contamination.
4. Include existing research, especially regional data sets; for example, Soil Conservation Service (SCS) and USGS regional surveys.
5. Utilize other agency expertise and support, such as SCS, Extension Service, Economic Research Service, and other university personnel.
6. Identify a select team of individuals for the regional MSEA effort having a demonstrated ability to generalize (regionalize).

## MSEA Review and Evaluation

Five review and evaluation reports and on-site reviews documented the progress achieved over the last year. The structure of individual evaluation reports generally followed a specified format to facilitate review. **The Review Teams were very impressed** with the general progress made at the five MSEA project locations. The following is a brief description of each of the MSEA projects.

### IOWA

### Assessment

Principal Investigators

| Name | Title and Affiliation | Area of Expertise |
|---|---|---|
| J. L. Hatfield, co-PI | Director, Natl Soil Tilth Lab USDA/ARS, Ames, Iowa | Microclimate-farming systems |
| J. L. Baker, co-PI | Prof, Agric Engr, Iowa State Univ | Soil chemistry, soil water |
| P. J. Soenksen, co-PI | Hydrologist, US Geological Survey | Ground/surface water quality |

There are over 30 active investigators from both State and Federal agencies.

Project Goal

The goal of the Iowa MSEA is to evaluate the effects of various agricultural management systems on ground water quality in three regions of the State.

Site Description

The Iowa MSEA is centered on three major sites -- the Western Region, Central Des Moines Lobe, and the northeastern Nashua area. The sites are characteristic of 35 percent of the land in the State that has been used primarily for corn or corn-soybean rotation. Small areas of Iowa are native or seeded pasture, or are cultivated small grain or alfalfa.

Western Region. The western MSEA site at Treynor is in an area known for well drained silty textured soils developed in deep loess that overlies a more compact, rolling glacial till which often has a layer of dense clay at the loess-till contact. The topography of the region is characterized by narrow, gently sloping ridges, steep side slopes, and well-defined alluvial valleys. The upland soils are well drained and have a high water-holding capacity. Under cultivation, they are highly erosive. The strata overlying the Mississippian aquifer are undifferentiated sandstone and shale. The structures of the soils and the strata provide a good opportunity for study of the transport and fate of water and chemicals. A comprehensive database exists at this site which enhances the water quality research being undertaken.

Des Moines Lobe. Approximately 20 percent of the topography of the Des Moines Lobe area is nearly level to gently rolling, and is intensively cultivated. Drainage varies from well-drained, moderately permeable soil with high water-holding capacity to poorly drained, moderately permeable soils with higher clay content.

The Mississippian Aquifer underlies the Des Moines Lobe area. The Des Moines River Valley and the Skunk River Valley are discharge areas for the aquifer and ideally water permeating the soils would flow through the glacial drift and into the aquifer to the river valleys. However, the movement from the root zone through the vadose zone is not well understood, offering an opportunity for MSEA research.

Nashua. The Nashua area ranges from level to gently rolling. The soils of the region, which are characteristic of 10 percent of the State, are formed from glacial loam till and have a high water-holding capacity with moderate to poor drainage. The Silurian-Devonian aquifer, characterized by carbonate and yielding large quantities of water in some localities, underlies the Nashua area.

Water Quality. Shallow wells in all three regions indicate nitrate and pesticide leaching. A 1988 assessment of the Western site showed that the median nitrate nitrogen concentrations in water was 1.8 mg/l in wells less than 15 m deep, and 1.3 mg/l in wells more than 15 m deep. Twenty-four percent of wells less than 15 m deep had atrazine concentrations of 0.1 to 24 ug/l, with a median of 0.3 ug/l. Pesticide concentrations increased during the summer. Additional studies at the Treynor Station in 1990 assessed the levels of nitrate and pesticides throughout the root zone and, at selected locations, to a depth of 5 m.

Des Moines Lobe water use and quality are similar to the Western region, with nitrate and pesticides reported in the shallow wells. These substances also were detected in the tile flow and runoff from agricultural fields, with more than 70 mg/l nitrate in tile flow and 7.0 ug/l atrazine in some areas.

Studies begun in 1990 to determine cropping histories on several fields will monitor tile flow, surface runoff, and transport of water and chemicals. Baselines of nitrate and pesticides in the soil will be established. Different soil-map strategies also will be analyzed. The Till-Hydrology site, which has been monitored for a number of years, was equipped with a well nest in 1990 to collect samples from the vadose zone to be analyzed for atrazine and other pesticides.

The wells in the northeastern portion of the State (the Nashua site) are deeper and exhibit much lower concentrations of nitrate and pesticides than do those of the other two regions. Shallow wells in this portion of the State have the same characteristics as the other two regions.

In 1990 several water and soil samples were collected for analysis in each of four cropping systems. Surface runoff measuring systems were installed to measure runoff as well as transport of water and chemicals through the soil.

Project Objectives

The Iowa MSEA has four primary objectives.

1. To quantify the physical, chemical, and biological factors affecting the fate and transport of agricultural chemicals. The focus of the project will be on the four most commonly used pesticides in Iowa--atrazine, alachlor, cyanazine, and carbofuran. The research will measure the movement of these pesticides and their major degradation products in 14C-pesticide treated undisturbed soil columns. The persistence and degradation of pesticides and their degradation products in saturated and unsaturated soils will be assessed. The influence of surface conditions produced by different farming practices on the volatilization of atrazine and alachlor will be measured, as will the microbial degradation of pesticides and chemical processes in soils with varying amounts of organic matter and surface tillage.
2. To determine the effects of crop, tillage, and chemical management practices on the quality of surface runoff, subsurface drainage, and ground water recharge. This will require quantifying the effect of different tillage practices on the efficiency of N-fertilizer uptake and evaluation of the movement of 15-N under different soils and tillage conditions. The effect of tillage and crop rotation on the movement of nitrogen and pesticides in a glacial till and loess soil will be evaluated, as will the impact of changing farming practices on the hydrologic balance and the fate and transport of nitrogen and pesticides.
3. To integrate information from Objectives 1 and 2 with data about soil, atmospheric, geologic, and hydrologic processes to assess the impact of these factors on water quality. This will require the use of root zone models to test the effect of changes in the farming system on nitrogen and pesticides in the soil and vadose zone. The origin and flow of water will also be

mapped in order to track the movement of chemicals to the ground water. The impact of changing farming systems on the quality of runoff, soil solution and ground water also will be assessed.

4. To evaluate the socioeconomic effects of current and newly developed management practices that will emerge from Objectives 1, 2, and 3. The MSEA will design and evaluate innovative farming systems that are environmentally sensitive and economically competitive. A landscape or watershed model using GIS or watershed programming techniques will be used to achieve this objective. Based on the results of the research program, recommendations and technical assistance will be provided to farmers in the region. The socioeconomic effects of new management strategies will be monitored, and the results will be conveyed to policy makers.

The objectives are ambitious and well-defined. Accomplishment of the objectives will require coordinated efforts by all members of the Iowa MSEA Team. Development of a comprehensive work plan with a timetable for completion of tasks will be an important guide to accomplishment of these objectives.

Major Hypotheses

The hypotheses have not been written for each of the objectives, an important step in measuring progress toward a goal.

Experimental Design

The experimental design utilizes field research plots and watersheds from existing long-term studies with added new experiments and new farming systems. The design appears adequate, although the Iowa MSEA site would benefit by having a comprehensive program plan. Some concern was raised regarding possible contamination of ground water from neighboring plots at the Till-Hydrology site. At the Treynor site, a detailed stratigraphic description of each watershed is needed from the surface to the saturated loess overlying the till.

The following is a brief description of the research design for the three major sites:

Western Region. The Deep Loess Research Station has been in existence since 1964 with four watershed agricultural sites. Presently watersheds #1 and #2 are operated with a cropping practice of continuous corn. Watershed #3 uses continuous corn with minimum tillage; watershed 4 is operating as a double-spaced parallel terrace system with underground pipe outlets and a ridge-till system. The review panel was favorably impressed by the long history of erosion, tillage and nitrogen management research conducted at Treynor and felt that expanded water quality research at the site provided many opportunities

This variety of systems allows comparison of runoff and water movement in three crop management systems. Complete documentation on the application rates and time of nitrogen fertilization and pesticide treatments should be provided through the life of the project. There are plans to initiate a no-till, strip-cropping rotation farming system on one of the watersheds in 1992. Detailed studies need to be conducted on the movement and persistence of atrazine and nitrate in the soil profile. The deep soils provide an analysis of the rates of movements and the transformations. Deep wells have been installed to examine these movements within the root and vadose zones. Within each watershed, the hydrologic balance needs to be measured to examine the patterns of water and solute movement in different systems.

Des Moines Lobe. The research design at the Till-Hydrology site and the Walnut Creek watershed encompasses both existing and new farming systems. Till-Hydrology site, a small station located near Boone, Iowa, measures the movement of chemicals and the age of water at various depths. The cropping systems that have been used at this site include continuous corn and a corn-soybean

rotation with documented amounts of nitrogen and pesticide applications. The review team felt that additional research could be established whether subsurface lateral flow negate or interfere with crop rotation and tillage effects at the Till-Hydrology site.

The cropping systems within the Walnut Creek watershed have been surveyed and farms have been selected for project participation in 1991. Current management systems include corn-soybean rotation, continuous corn, and corn-soybean-grain-legume rotation. Fields have been selected in the Walnut Creek watershed which represent portions of the landscape. These fields are being monitored for surface runoff, tile flow and ground water quality with automated samplers to collect the water moving through different portions of the landscape. A selected subbasin (320 ha) has been selected, with wells installed to measure the hydrology and water quality below the tile line. The outlet of the tile and surface runoff from this subbasin will be measured to provide an assessment of a collection of fields on water quality.

Within these fields soil sampling will be conducted to determine the amounts of pesticides within the root zone throughout the year. At three locations along the stream automated stream flow and quality collection devices have been installed to collect the water from various portions of the landscape. Within one portion of a selected field, a pothole is being studied to determine the movement of water, pesticides, and nitrate and the transformations across a varying landscape.

Nashua. Three crop rotations exist at the Nashua site: continuous corn, corn-soybean, and soybean-corn. The crops are grown under four different tillage practices: ridge-till, no-till, moldboard plow, and chisel plow-disk. Alachlor and atrazine have been applied each year to the continuous corn crop, along with nitrogen, phosphorus, and potassium. Alachlor and metribuzin, along with nitrogen, phosphorus, and potassium have been applied to the corn-soybean rotations. No change in the farming systems are planned for the first two years of the project; after this time period, an effort possibly will be made to change the amount and interval of nitrogen applications. Tile flow is monitored in each plot with an automated sump pump system which measures the flow amounts and then collects a water sample on a periodic schedule. Surface runoff will be collected in four of the plots to provide a measure of nitrate and pesticide loss from the soil surface. The review team felt that interflow could be occurring between the plots and subsurface drains at Nashua.

Data Collection Approach

Laboratory and field equipment already installed are state-of-the-art and functioning properly. Documents are being written that describe procedures and protocols in order that each investigator can effectively share the data.

Database Design and Approach

The database design is adequate; however, plans for exchange of data are not complete. The database will be essential to developing or testing models. The models to be tested should be identified so that the database contains the appropriate data. Procedures for the sharing of data among the Iowa sites are being developed in the Walnut Creek as an example.

Analytical Approach

The analytical tools appear to be appropriate and well-designed. However, the model and decision aid component could use greater attention. Several models now available are being incorporated into the research.

1. SOILSIM. This model describes the processes within the root zone.
2. Root Zone Water Quality Model. This one-dimensional model is currently being evaluated at a number of ARS stations. It will be expanded to a two-dimensional model for use with the MSEA project.

3. Pesticide Root Zone Model (PRZM) and Groundwater Loading Effects of Agricultural Management Systems (GLEAMS). These are both process models containing a number of simplifying assumptions that may limit their usefulness in assessing small changes in the surface features of soil. The one-dimensional structure of the model and the daily time step may not allow the resolution of processes controlling fate and transport of nitrate and pesticides in the soil root zone.
4. Walnut Creek Watershed Models. The model, presently being developed by USGS, will be used to predict changes that will occur within Walnut Creek watershed. It will serve as a basic framework into which other models can be incorporated. In addition, both micro- and macroeconomic models will be developed by ISU and ARS for the evaluation of alternative farming practices on this watershed.

Quality Assurance/Quality Control

An excellent plan was presented. Appropriate QA/QC protocols have been developed and MSEA data will meet QA/QC standards. Dr. Hatfield and the QA/QC committee have prepared an excellent plan for use by all the MSEA sites.

Management Organization

All of the investigators are active participants in the fact-finding and decision-making process and are aware of the project goals and overall timeframe of the project. The investigators need to be aware of the importance in sharing their information and working in multidisciplinary teams to meet the project goals.

Technology Transfer

The project appears to be waiting until additional extension personnel are employed before a technology transfer plan is developed. A regional coordinator of extension is to be employed and located in Iowa. It is important that the coordinator serve all the MSEA sites. The Iowa MSEA needs to move forward with a technology transfer plan.

Interagency Linkages

Interagency linkages with ISU, ARS, USGS, and EPA is good. The concept of interaction is based primarily on the ability to take advantages of different scales of expertise from the cooperating agencies. Involvement with the Soil Conservation Service (SCS) and Cooperative Extension Service (CES) for enhanced technology transfer is encouraged.

Anticipated Results/Time Frames

A list of project personnel and their activities was provided along with a list of project subobjectives.

After the review, products and timelines were provided for the various project subobjectives. An updated project document with products and timelines will be completed in early 1992.

Likelihood of Attaining Objectives

Objective #2 will be difficult to attain. The effect of tillage will be a complicating factor to the movement of nitrate and pesticides. Separating the effects of cultural practices from crop rotation effects will be a challenge. Mineralization and denitrification are also complicating factors.

Transferability, Scale Up, Regionality Potential

The Iowa MSEA project has an excellent opportunity to investigate transferability since the three sites span the State. Scale up potential is excellent since research is being conducted across the scale from small plots to field scale to entire watersheds. Plans for regionalizing research results appear to be weak. Iowa could serve as a model for extending research results to new areas within the State and to other States.

## Recommendations

The MSEA Study

1. The model and decision aids component of the Iowa MSEA needs greater emphasis. Plans should be developed for model/decision aid testing.
2. The Iowa MSEA needs to determine whether subsurface lateral flow is likely to negate or mask crop rotation and tillage effects at the Till-Hydrology and Nashua sites; consider adding a controlled drainage study to increase denitrification before water leaves the tile field at the Till-Hydrology site; and develop a subsurface map of the underlying till landscape at the Treynor site. Additional studies have begun on lateral flow at all of the sites.
3. The Iowa MSEA needs to develop a program plan of work that includes major hypotheses, a delineation of how and who will test each hypothesis, data collection protocols, and a timeframe in which the work is to be accomplished. The plan will be completed in early 1992.
4. The Iowa socioeconomic surveys and studies could be linked more closely to other MSEA projects. Possibly, a more directed survey and focused study should be developed.
5. The Iowa MSEA could serve as a model for extending research results to specific regions or locations in Iowa or to other States.

MSEA Management Team, Research Committee, Agencies

1. The MSEA Management Team needs to encourage a wider base of responsibility for planning, conduct of research and publishing results.
2. The Research and Development Committee of the Working Group on Water Quality needs to encourage regionalization of results.
3. ES, ARS and CSRS need to define the duties of the regional extension coordinator.
4. Agencies should commend the Iowa MSEA for the assembly of an outstanding team of investigators, appropriateness of the sites selected and outstanding progress.

## MINNESOTA

Satellite Locations in Wisconsin, North Dakota, and South Dakota

## Assessment

Principal Investigators

| Name, State,& Co-PI | Title and Affiliation | Area of Expertise |
|---|---|---|
| R. H. Dowdy, MN | Soil Scientist, USDA/ARS, St. Paul | Soil Chemistry |
| J. L. Anderson, MN | Assoc. Professor, Univ of Minnesota | Soil Genesis/Morph. |
| G. N. Delin, MN | Hydrologist, USGS, St. Paul | Hydrology |
| G. D. Bubenzer,WI | Professor, University of Wisconsin | Agricultural Engineering |
| R. E. Knighton, ND | Asst Professor, ND State University | Soil Physics |
| A. R. Bender, SD | Professor, SD State University | Climatology |

Project Goal

The goal of the Minnesota MSEA is to implement an improved agricultural management system and evaluate its impact on ground water in representative sand plains within four geographic settings. To accomplish this goal, the project will: (1) provide the settings for multidisciplinary, multiscale research on the processes and factors affecting the movement, storage, and transformation of agricultural chemicals in the sand plain hydrological environment common in the Midwest Cornbelt; and (2) integrate the deterministic and statistical data collected by federal, state, and local agencies within this research project.

Background Information

The MSEA sites are the Anoka Sand Plain in Minnesota, the Wisconsin River Sand Plain in Wisconsin, the Oakes Irrigation Research area in North Dakota, and the Big Sioux Aquifer area in South Dakota.

Pesticide surveys, field-scale experiments, and regional studies indicate that the sand plain hydrological setting is one of the most vulnerable to contamination. Contamination from point and nonpoint sources, including farming, septic systems, landfills, suburbanization, and road de-icing salts, has been found in Minnesota, Nebraska, Iowa, Wisconsin, and Illinois; all of these states are characterized by sand plain aquifers. This study, which concentrates on the Anoka Sand Plain aquifer in Minnesota, with satellite sites in Wisconsin, South Dakota, and North Dakota, will be transferable to other sand plain areas in the Midwest.

Hydrology. Plot and field-scale (approximately 1.5 to 16 hectares) research sites have been established in sand plains within Minnesota, North Dakota, South Dakota, and Wisconsin. Characterization of the physical and chemical properties of the soil and of the aquifer (vadose and saturated zones) has progressed rapidly at each of the field-scale locations.

Site Descriptions

Anoka Sand Plain (Minnesota Site). The principal site is located in the Anoka Sand Plain near the town of Princeton, Minnesota. The Anoka Sand Plain aquifer covering about 4,400 square kilometers constitutes one of the largest surficial aquifers in Minnesota. The aquifer consists primarily of gray, calcareous outwash (Des Moines lobe) and is considered typical of sand plains throughout the Midwest Cornbelt. The Anoka Sand Plain is characterized by extreme values in many of the hydrogeological factors affecting the fate and transport of atrazine such as high hydraulic conductivity (soil, unsaturated, and unsaturated zones), shallow depth to the water table, flat topography and low runoff, high rates of recharge and ground water seepage, high baseflow or seepage to surface water bodies, low organic carbon, low sorption to aquifer matrix, and large annual temperature fluctuations. Because of these characteristics, sand plain aquifers are very sensitive to land surface practices.

The principal research site is about 5 kilometers southwest of the town of Princeton and about 80 kilometers northwest of Minneapolis and St. Paul. Material in the unsaturated and saturated zones generally consists of fine-to-medium sand and medium-to-coarse sand, respectively. A 5- to 35-centimeter thick silty layer at a depth of between 1.2 and 2.7 meters below land surface was identified within the unsaturated zone in several core holes drilled on the site perimeter. Depth to the water table is approximately 3.6 meters below land surface and the saturated thickness is between 5 and 12 meters. Saturated hydraulic conductivities are about 0.04 centimeters per second, ground water velocities are about 5 cm/day. Clay-rich till of lower permeability underlies the surficial aquifer.

Ground water flow is generally from West to East through the site. Streams form natural hydrologic boundaries around the site. Ground water discharges primarily to Battle Brook and an associated wetland located in the northeast corner of the site. The ground water flow gradient is

about 1 meter per kilometer and the ground water recharge rate is about 20 centimeters per year. The potential for previous up-gradient agricultural chemical use is minimal at the site.

Water Quality. Surface and ground waters are of the calcium-bicarbonate type at the Princeton site. Ground water samples collected from 14 wells at the site in April 1991, before application of agricultural chemicals, had nitrate-nitrogen concentrations of between 0.02 and 19.92 milligrams per liter and a mean concentration of 8.22 milligrams per liter. Concentrations of chloride in the 14 wells were between 0.56 and 25.70 milligrams per liter and had a mean concentration of 11.43 milligrams per liter. Sulfate concentrations ranged from 0.90 to 43.30 milligrams per liter and had a mean concentration of 9.45 milligrams per liter. Values of pH ranged from 5.90 to 8.30 with a mean of 7.29.

Values of specific conductivity ranged from 142 to 490 microsiemens per centimeter at 25°C and had a mean value of 279 microsiemens per centimeter. Concentrations of dissolved oxygen were between 3.62 and 10.5 parts per million and had an average value 7.12. Alkalinity ranged from 16 to 179 milligrams per liter as $CaCO_3$ and had an average value of 95. Immunoassay tests for trazines and alachlor were performed as a preliminary qualitative screening tool for those herbicides before quantitative GC/MS analysis. Of the 14 wells samples at the site, three wells had positive detections for triazines and one well had a positive detection for alachlor. A sample collection from Battle Brook along the north edge of the site tested positive for both triazines and alachlor.

Soil. The dominant soil association on the Anoka Sand Plain consists of the Zimmerman, Isanti, and Lino series. These soils occur on broad undulating outwash plains across east central Minnesota, and were formed in fine-textured sandy sediments. All three soils have a surface layer of loamy fine sand and a subsurface of fine sand; distinctions between the types are related to soil drainage which varies with landscape position and depth of the water table.

The Zimmerman soil occurs on broad undulating uplands and narrow escarpments, and is excessively drained. Native vegetation was mixed oak forest. The Lino series, which is poorly drained, is found on small flats, depressions, and drainageways. Native vegetation was mixed hardwood forest. The Isanti soil is found in depressions and on low-lying flats and is very poorly drained. The soil has marsh vegetation. All three soils are slightly to strongly acid (surface pH between 5.1 and 6.0), are highly permeable (15 to 50 cm/h), and have very low water-holding capacities (less than 0.1 cm. of available water per cm of soil). Wetness associated with the high water table is the major restriction affecting agricultural land uses.

Weather and Climate. The average water balance for the area based on records from 1910-70 is: Precipitation is 70 cm per year (balanced by runoff of 15 cm per year and evapotranspiration of 55 cm per year), where about 20 of the 70 cm circulates through the surficial aquifer system with negligible change in storage over the long term. The mean monthly precipitation in the Anoka Sand Plain ranges from 20 cm in January to 125 cm in June. Evapotranspiration is greatest in June, July, and August. Ground water discharge of water to rivers ranges from 2-5 cm a year. Average daily minimum temperatures range from -18°C in January to 15°C in July; average daily maximum temperatures range from -7°C in January to 28°C in July.

Land Use. A 5-year lease permitting access to 65 hectares for experimental purposes has been executed. Urbanization and conversion of agricultural land to home and business sites have introduced a variety of sources of contamination within the region.

Wisconsin River Sand Plains (Wisconsin Satellite). Extensive detections of atrazine in ground water along the lower Wisconsin River explain the intense research and outreach activities related to ground water. An extensive program of sampling domestic wells is underway, as well as research and education efforts by state agencies. Primary focus of field management systems is on soil type (Sparta vs. Plainfield), tillage practices, and other best management practices. The soils are deep permeable sands that are farmed intensively.

Oakes Irrigation Research Site (North Dakota Satellite). The aquifer system in the area consists of medium sand to gravel. There is till at approximately 9 inches. Depth to the surface of the aquifer is approximately 3 m. Small plot and lysimeter research data have been collected at this site since 1980. Annual precipitation averages 45 cm. Runoff is generally 2 cm or less, and 23 cm of water circulates through the aquifer at the irrigation site.

Big Sioux Aquifer (South Dakota Satellite). The general area includes the Oakwood-Poinsett Rural Clean Water Project, South Dakota State University experimental sites, USGS aquifer studies, and various studies conducted by the Environmental Protection Agency. The aquifer itself is shallow with the water table within 4.5 m of the surface and an average aquifer thickness of 3 m. The entire drainage basin for the aquifer is approximately 3,000 $km^2$ in extent covering much of eastern South Dakota. Annual precipitation for this area is 53 cm. The annual water budget is: Precipitation (53) - Runoff (8) + Evapotranspiration (45); where about 10 cm circulates through the aquifer system. Continuous monitoring of water quality began in 1989. Water levels have been monitored since 1976 when a rural water supply field was established. These wells and other monitoring wells are sampled for nitrate.

Project Objectives

The project will determine whether herbicides and $NO_3$ used in a ridge-till corn and soybean cropping system reach ground water. If herbicides are found in ground water in areas where these agricultural practices are used, the effects of agricultural practices on water quality will be correlated with conditions of hydrology and water flow.

The specific research objectives of the project are:

1. To investigate the impacts of ridge-till practices in a corn and soybean cropping system on ground water quality and on the rate of transport of atrazine, alachlor, and metribuzin in saturated and unsaturated zones.
2. To determine the effects of nitrogen management by soil test and plant analysis.
3. To characterize ground water flow through the sand and gravel aquifers represented and relate their characteristics to the transport and storage of agrichemicals.
4. To determine the relation between ground water recharge rates and rates of agricultural chemical loading to ground water.

The objectives are appropriate for the mission of the MSEA project. The emphasis upon the effects of nitrogen and pesticide management on ground water quality should be encouraged.

Minnesota--All the objectives apply and are appropriate.
Wisconsin--Appropriate objectives which fit with other site objectives.
North Dakota--Tied closely to the Demonstration Project with less well-defined MSEA objectives.
South Dakota--Excellent emphasis on herbicide chemistry and close tie to component research. MSEA component should have a standard for comparison.

Major Hypotheses

Lack of control treatments makes testing of hypotheses difficult at the satellite sites in Wisconsin, North Dakota and South Dakota.

Minnesota--Coordinated field and component research should make testing of major hypothesis feasible.

Wisconsin--Strong component research in soil physics relating to unsaturated flow makes testing of hypothesis possible.

North Dakota--Testing of major hypotheses appears impossible without a control treatment.

South Dakota Component research on BMPs is excellent; however, ability to test MSEA hypotheses is weak.

Experimental Design

Three farming systems are being evaluated at the Princeton MSEA site: (a) a corn-soybean rotation utilizing ridge-till to reduce pesticide use; (b) a chemically intensive, sweet corn-potato rotation in widespread use in the northern sand plains, utilizing ridge-tillage, and (c) continuous corn utilizing conventional tillage and pesticide and fertilized application procedures.

At each of the satellite sites in Wisconsin, North Dakota and South Dakota, a common farming system (System A)has been established. The characteristics of these farming systems are listed below:

System A: Field corn/soybean production.

Crop rotation and tillage: Field corn/soybeans with both crops occurring each year, ridge (not a full width) tillage system.

Fertilization rate: As recommended by soil test from the University of Minnesota.

Pesticide usage: Atrazine, alachlor, and metribuzin according to WEEDIR (Minnesota Extension Service, 1990B) or a better successor guide. Insecticide according to INSREC (Minnesota Extension Service, 1990c).

Irrigation: As predicted by state of the science irrigation scheduling system which optimizes production and uses precipitation risk to minimize leaching.

Fertigation: Will be used to maximize application flexibility and nitrogen use efficiency.

The ridge tillage system reduces pesticide usage because the herbicides are applied only in the immediate vicinity of the row, while weed control in the inter-row is accomplished almost completely by cultural and mechanical means. A cover crop planted in early fall and killed in winter will be used following the soybean crop to control wind erosion and minimize nitrate movement during winter. It is possible to rely on crop residue for erosion control and nitrate immobilization following the corn crop.

System B: Sweet corn-potato production.

Crop-rotation/tillage: Sweet corn-potato with both crops each year treated with full-width tillage.

Fertilization rate: As recommended by soil testing of University of Minnesota with banded application.

Pesticide usage: Atrazine, alachlor, and metribuzin only according to WEEDIR or a better guide; insecticide use as determined by INSREC.

Irrigation: As predicted by an irrigation scheduling that optimize production and uses precipitation risk to minimize leaching fraction.

Fertigation/vine killing: For potato only; a vine killer may be needed for early harvest to enhance cover crop establishment.

The use of a full-width tillage system consisting of disk, chisel, and field cultivators will accentuate crop residue retention on or near the soil surface to control wind erosion. Sweet corn residues incorporated immediately after harvest in August will have a green manuring action. A legume/nonlegume mixture that is not winter-hardy will be used for cover crop. Early potato harvest facilitated by a vine burn-down will be used to emphasize cover crop protection (nitrate scavenging, reduced soil erosion, weed competition). After potato harvest, there will be limited or no tillage in spring to avoid wind erosion in the planted sweet corn. Repeated tillage may follow the corn crop, but residue clearing devices on the planter will be implemented in a departure from the current practice of moldboard plowing.

System C: Continuous corn.

- Crop-rotation/tillage: No rotation, full-width chisel plow tillage.
- Fertilization rate: Current University of Minnesota recommendations.
- Pesticide usage: Atrazine and alachlor according to current WEEDIR recommendations, insecticide use determined by INSREC.
- Irrigation: Excessive amounts of water applied.
- Fertigation: Will be used on an 'as needed' basis.

This system will be established in the USGS ground water recharge area. It is a conventional system except there will be excessive irrigation water applied to ensure that the applied chemicals will move to ground water.

Coordination between locations has not produced a common design which includes a control treatment that is similarly managed at all locations. There is a good research plan for each of the sites which is supported by well-established and instrumented sites. However, the ability to evaluate the management system studied against a control or comparison site seems to exist only at the Wisconsin site. Evaluation based on yield comparisons with recommended practices or "before and after" presents several potential difficulties, such as how well recommended practices are accepted, and difficulty in clearly defining the reasons for differences over time. Yields can be dramatically affected by weather, and a comparison or control site is vital to account for such abnormalities which greatly affect farmer practices and attitudes. Evaluations must also go beyond yield to take into account important economic, sociological and water quality considerations. It does not appear that ground water dynamics are well enough known at several sites to be sure measured ground water effects are due solely to management systems evaluated, especially when only a limited number of ground water monitoring sites or wells can be installed.

- Minnesota--Excellent experimental design for characterizing water flow and agrichemical fate and transport at a sand plains MSEA site.
- Wisconsin--Experimental design for unsaturated flow studies appears appropriate and well designed.
- North Dakota--Experimental design for ground water quality sampling lacks a control component and has insufficient sampling and monitoring.
- South Dakota--Lysimeters and unsaturated flow studies indicate a good experimental design. Overall MSEA design is weak.

## Data Collection Approach

The four primary agricultural chemicals being analyzed in water at the Northern Cornbelt Sand Plain MSEA are atrazine, alachlor, metribuzin and nitrate. Other pesticides also will be analyzed, if applied to the crops. Analyses for several degradation products of atrazine (desethylatrazine and deisopropylatrazine) and alachlor (chloroalachlor and hydroxyalachlor) will also be included. Many of the processes affecting the fate and transport of agricultural chemicals in the atmosphere, soil/root zone, unsaturated zone, saturated zone, and surface water will be evaluated including volatilization, atmospheric transport and deposition, plant uptake and bioaccumulation, mass transport and biodegradation, and effects of macropore flow.

Comparisons of agrichemical concentrations collected both annually and throughout the duration of the study will be made. Data collected at each of the sampling points at the primary site near Princeton will be compared and plotted to provide an evaluation of the spatial distribution of the chemicals in the saturated and unsaturated zones. These will be compared to similar data collected at the satellite sites in North Dakota, South Dakota, and Wisconsin to evaluate the effects of the ridge-tillage farming system in different climatic settings in northern cornbelt sand plains. Similar data collected in the watershed and sand plain immediately surrounding the Princeton MSEA site may also be compared to this data set to provide a relationship to these different scales of evaluation.

The data collection approach appears adequate; however, no clear plan was presented to show how data will be shared or merged with other Minnesota satellite locations or with other MSEA sites. Development of a common database is very important and beneficial.

Minnesota--Needs to establish procedures for a common database for research sites.
Wisconsin--Collection of economic data is lacking or unclear. Relationship of Wisconsin data to Minnesota or other locations is not clear.
North Dakota--Data collection procedures are incomplete and need further refinement.
South Dakota--Event-oriented data collection approach is appropriate. Component research looks good. Relationship to Minnesota data appears unclear.

Database Design and Exchange

The Review Team found no organized plan for database design and exchange within the Minnesota MSEA or in cooperation with other MSEA sites. Leadership in developing the database design should come from Minnesota. The satellite sites in Wisconsin, North Dakota, and South Dakota appeared to have no organized database plan and they appeared to be waiting for Minnesota to develop the plan. Database development must be coordinated among the sites.

Analytical Tools

The analytical tools for Minnesota, Wisconsin, North Dakota and South Dakota appeared adequate and appropriate for the projects.

Quality Assurance/Quality Control

The QA/QC procedures used at all sites--Minnesota, Wisconsin, North Dakota, South Dakota--seemed to be appropriate and adequately implemented.

Management Organization

The management for the project (including cooperating sites) seems to be centralized in Minnesota. The cooperators (Wisconsin, North Dakota and South Dakota) appeared to have had limited input into the overall planning and decision making for the project. This may be due partially to distance and smaller portions of the overall project being conducted at the satellite sites. The principal investigators at all sites are capable and cooperative.

Technology Transfer Plans

Minnesota has an Extension Specialist working on the MSEA project. The dynamic education and public participation program initiated under RCWP for the Big Sioux aquifer system in South Dakota can serve as a model for the Extension function at each project site. This can provide excellent support and direction for the Minnesota leadership to deliver an Extension outreach

program to the public throughout the four states. This represents a tremendous opportunity but also a large challenge in view of the small amount of project funds that apparently are being devoted to support extension specialists for this project.

Minnesota--The Extension Specialist needs to work closely with the satellite sites and other MSEA locations.
Wisconsin--An Extension person is identified to work with the MSEA. Plans appear adequate.
North Dakota--No technology transfer plan was identified.
South Dakota--Adequate technology transfer plans; however, no clear plan was presented for coordination with other sites.

Interagency Linkages

The linkages between the Minnesota Agricultural Experiment Station, the University of Minnesota, ARS, USGS, EPA, and SCS appear excellent at the Minnesota MSEA site. The leadership and involvement by USGS personnel at the Minnesota MSEA is by far the strongest of any of the MSEA sites. USGS personnel participate as full partners in the Minnesota MSEA program.

Minnesota--Excellent cooperation and coordination with other federal and state agencies.
Wisconsin--Excellent linkage with the state water regulatory agency; however, linkages with USGS, EPA, and SCS were unclear.
North Dakota--Linkage with the Bureau of Reclamation; however, linkages with EPA and SCS were not apparent.
South Dakota--Linkages to other agencies were not clear.

Anticipated Results/Timeframe (Products)

Expected results from research at the Minnesota MSEA include: (1) development of agricultural systems that reduce the movement of agricultural chemicals to ground water, (2) improved knowledge of the processes and factors affecting the movement of agricultural chemicals to ground water, (3) establishment of a database relating farming systems, hydrogeological factors, and water quality in varying climatic settings, and (4) educational material for farmers and the general public reporting the socioeconomic impacts of the ridge-tillage system compared to a conventional farming system.

A report(s) will be prepared in 1991-92 providing a description of: (1) research objectives and hypotheses, (2) hydrogeologic setting, soils, and ground water flow at the MSEA site, (3) cropping systems plan and plot layout, (4) soil and water quality sampling network design, (5) data collection and management plans, (6) laboratory and field procedures for collection of soil and water samples, (7) quality assurance and quality control protocols for data collection, and (8) use of models.

A journal article(s) will be prepared documenting preliminary results of soil and water sampling conducted during the first year of the study. Included in this document(s) will be a description of the effects of ridge-tillage on water quality for corn/soybean and sweet corn/potato cropping systems. Additional journal articles may be prepared during succeeding years documenting ongoing research results. An interpretive report will be prepared in 1995-1996 summarizing MSEA research based on results from data collected during the duration of the project.

The Minnesota MSEA has excellent prospects for meaningful results on the effects of management practices upon water quality and characterizing fate and transport of agrichemicals. To make comparisons with satellite location data, a benchmark for control between sites needs to be established. The timeframe and products identified are appropriate.

Minnesota--Excellent prospects for meaningful results.
Wisconsin--Excellent prospects for meaningful results.
North Dakota--Lack of a standard or control inhibits comparison of management treatments.
South Dakota--Good prospects for meaningful results in unsaturated flow and movement of herbicides. A control for comparing management systems is unclear.

Likelihood of Attaining Results

Minnesota and the satellite locations in Wisconsin and South Dakota have good prospects for achieving their stated objectives. However, the review panel felt that the experimental design needed improvement in North Dakota. The project would be strengthened by including a common control at all sites to provide a standard for comparison between locations.

Transferability, Scale Up, Regionality Potential

Due to the location of research sites in four states with variations in climate and soils, the Minnesota MSEA project is in a prime position to investigate transferability and scaling up of results. Minnesota and the satellite locations in Wisconsin, North Dakota and South Dakota are encouraged to include transferability of results to the Midwest regions as an objective. As presented in the review, excellent data exist concerning soils of the region. The soils database coupled with regional models could provide valuable regional applications.

## Recommendations

The MSEA Study

1. A common data acquisition, management and exchange plan for the Minnesota, Wisconsin, North Dakota, and South Dakota sites needs to be developed with a common set of models to be tested. A control treatment common to all sites is essential for regional comparisons.
2. Cooperators from the satellite locations--Wisconsin, North Dakota, and South Dakota--should participate more actively in the planning and operation of the project.
3. North Dakota and South Dakota sites should develop a more effective linkage with other state and federal agencies.
4. The Minnesota MSEA location should ensure that adequate computer facilities are available for validation of water quality research models for all project sites.
5. A technology transfer plan needs to be developed which outlines the role of the Extension Specialist in Minnesota and the techniques to be used for cooperating and networking with all project sites. This plan should be consistent with the plans being developed by the overall MSEA Extension Coordinator in Iowa.

MSEA Management Team, Research Committee, Agencies

1. MSEA Management Team needs to encourage a closer linkage of the satellite studies with the principal project in Minnesota.
2. ARS and CSRS needs to commend Minnesota on the outstanding involvement of USGS in the project.
3. The Research and Development Committee of the Working Group on Water Quality needs to encourage the transfer of results to other sites and across the region and among other MSEA projects.

## MISSOURI

## Assessment

### Principal Investigators

| Name | Title and Affiliation | Area of Expertise |
|---|---|---|
| E. E. Alberts, co-PI | Soil Scientist, USDA/ARS, Columbia | Erosion/deposition |
| A. A. Prato, co-PI | Professor, University of Missouri | Agr. Economics |
| S. Anderson | Asst Professor, Univ of Missouri | Soil physics |
| P. Blanchard | Asst. Professor, Univ of Missouri | Hydrogeology |
| D. Blevins, co-PI | Hydrologist USGS, Missouri | Hydrogeological |
| W. W. Donald | Agronomist, USDA/ARS, Columbia | Weed science |
| A. T. Hjelmfelt | Hydr. Engineer, USDA/ARS, Missouri | Hydr. Engineering |
| S. C. Killpack | Extension Associate,Univ of Missouri | Soil/Wtr Conserv. |
| N. Kitchen | Agronomist, Univ of Missouri | N Utilization |
| K. A. Sudduth | Agricultural Engineer, USDA/ARS, MO | Agr. Engineering |

### Project Goal

The goal of the Missouri MSEA project is to increase knowledge needed to design farming systems, educational programs, and public policies to reduce agricultural contamination of ground and surface waters.

### Site Description

Missouri's MSEA is located in the Goodwater Creek watershed, an agricultural area north of Centralia. The site lies within a claypan soil region which represents about 10 million acres of midwestern soils. The principal extensive areas are in Missouri, Illinois, and Kansas. Secondary areas, where the soils are sufficiently like a claypan that claypan management practices apply, occur in Oklahoma, Indiana, and Ohio. Claypan soils of the Midwest prairie are problem soils. A clay sublayer, beginning at a depth of 18 to 20 centimeters, restricts air and water movement and retards plant root development. The upper horizons are usually low in natural fertility and are often acidic unless corrective treatments are made.

Hydrology. The hydrological characteristics of the area are such that nitrate and pesticide contamination of surface and ground waters in the Goodwater Creek watershed and surrounding areas may be a serious concern. Shrinking of the claypan by water stresses during the crop growing season can cause the subsoil to fracture, resulting in high macropore flow during soil water recharge periods. Second, hydrologic conditions indicate that Goodwater Creek is a recharge source for the major regional aquifer. Finally, Goodwater Creek flows into the Salt River which, in turn, empties into Mark Twain Reservoir, a public water supply and recreation area.

Water Quality. Water quality data have not been collected from the 38 domestic wells in the Goodwater Creek watershed to determine the extent of ground water contamination by agricultural chemicals in the watershed itself.
However, a rural well testing program showed that 36% of the wells sampled in a 5-county area, which includes the Goodwater Creek watershed, had nitrate-nitrogen concentrations in excess of 10 ppm.

Project Objectives

The Missouri MSEA project has seven major objectives, each of which has several subobjectives:

1. Assessment:
   Research to measure the effects of conventional and alternative farming systems on surface and ground water quality. Subobjectives are to evaluate the effects of farming systems on hydrology, erosion, dissolved nitrogen and pesticides in surface runoff, interflow, and ground water and chemical movement within the crop root and unsaturated zones.

2. Component:
   Research to study the mechanisms responsible for the fate and transport of agrichemicals in soil and water. Subobjectives are to evaluate the effects of basic soil and plant processes on pesticide fate and transport; determine the effects of basic soil processes on macropore and crack development and their effect on water flow; determine the effects of interflow over a claypan on pesticide and dissolved nitrogen fate and transport in the upper root zone; and determine the effects of riparian zones on the fate and transport of pesticides and dissolved nitrogen.

3. Scale:
   Research to determine how information from the field areas and research plots can be scaled up to watershed and/or regional levels. Subobjective is to determine differences in measured responses between large and small watersheds and identify the causes.

4. Modeling:
   Research to refine and develop models of the physicochemical, economic, and social processes affecting soil and water contamination from farming activities. Subobjectives are to evaluate selected water quality models to verify measured values for claypan soils; improve the accuracy of model predictions by developing new components representing processes not presently modeled; and develop model components that predict macropore and crack flow as influenced by wetting and drying, freezing and thawing, and other basic soil processes.

5. Prescription Farming:
   Research to develop and evaluate alternative cropping systems and technologies designed to protect water quality through the use of site-specific management techniques. Subobjectives are to quantify and to automate the measurement of in-field spatial variability in soil properties and crop yield; to develop methods to efficiently manage and utilize spatial data; and to implement systems using spatial data to precisely control pesticide and fertilizer application rates.

6. Socioeconomics:
   Research to establish the relative profitability of alternative farming systems and farmers' attitudes toward adoption. Subobjectives are to measure the potential impacts of widespread adoption of alternative farming practices on farm production, income, food prices, and rural communities; and assess the impacts of the MSEA project on landowners'/farmers' attitudes and behaviors regarding the use of alternative farming systems and the activities of local conservation districts, SCS, university extension, and other related agencies.

7. Education:
   Activities to develop educational programs to increase farmers' awareness and understanding of the relative profitability and environmental benefits of alternative farming systems. Subobjectives are to conduct workshops and demonstrations to inform farmers, extension specialists, soil conservationists, and legislators about the profitability and water quality effects of alternative farming systems; and develop publications and other educational materials to inform farmers, regulators, and extension specialists about research results.

The review panel felt the project objectives were consistent with the goals and objectives of the President's Initiative on Enhancing Water Quality. However, the review panel was concerned that the research plots may not lend themselves to evaluating the effects of farming systems on hydrology and chemical transport within the unsaturated zone (Objective 1). The review panel also recommends that any water quality research initiated on the plots be carefully planned and implemented to minimize the possible cross contamination of water and chemicals

Major Hypotheses

The researchers indicated that major hypotheses have been developed for the various project objectives. However, these hypotheses were not made available during the review and evaluation.

Experimental Design

Field Farming Systems (Field Areas). The following three farming systems will be evaluated on field-sized areas (20 to 40 hectares):

High agrichemical-use farming system: Corn-soybean rotation with high fertilizer and herbicide application for high yield-goal production (Farming System 1).
Medium agrichemical-use farming system: Sorghum-soybean rotation with fertilizer and herbicide application based on a long-term average yield, emphasizing profitability (Farming System 2).
Low agrichemical farming system: Corn-soybean-wheat rotation with nitrogen fertilizer application based on long-term average yields, soil testing, split fertilizer application, and a combination of herbicide banding and secondary tillage for weed control. Emphasis will be on profitability and water quality (Farming System 3).

Nitrogen fertilizer inputs will be variable across farming systems, whereas potassium and phosphorus will be applied to all systems based on yield goals and soil testing. Leachable herbicide input (atrazine and alachlor) will be graded from high to low in the farming systems by varying herbicide application rate in systems 1 and 2 and reducing herbicide rates through banding and secondary field cultivation in system 3. Primary tillage will be similar among farming systems. Crop scouting and recommendations for insect and disease control will be made by University of Missouri-Columbia (UMC) Integrated Pest Management (IPM) personnel. The review panel was impressed by the effort taken to select the three farming systems which appear to be most appropriate for the Goodwater Creek watershed.

Plot Farming Systems (Research Plots). The high and low agrichemical farming systems listed above will also be evaluated over a landscape of soils (0.3 hectare research plots). Three additional farming systems will be evaluated on plot-size areas:

- High agrichemical no-till corn-soybean rotation system.
- Low agrichemical ridge-till corn-soybean rotation system.
- No agrichemical continuous grass without harvest--like the Conservation Reserve Program.

The review panel felt that the criteria used for the selection of the farming systems and the research site areas were good and showed a great deal of thought and planning. The panel was not sure how the landscape differences in the 30 research plots would be evaluated. Component studies on crack development and interflow over the claypan are key to understanding the fate and transport of agrichemicals and water through the claypan soils.

Data Collection Approach

A summary of the data collection approaches is described for the seven project objectives.

1. Assessment:
   Precipitation, climatic, and chemical concentrations in rain and dust are to be measured using an automated weather station located in the MSEA Site #1 field 1. Rainfall is to be measured on the two other fields using recording rain gauges.

   Each of the fields is to be instrumented with a weir or flume, water stage recorder, and a refrigerated pumping sampler to measure erosion and dissolved nitrogen and pesticide concentrations and losses on an event basis.

   Five well nests are to be installed within each field to measure chemical concentrations in the ground water. Each nest will be comprised of two to four wells depending upon the depth to bedrock. Wells less than 7.5 meters deep will be sampled quarterly; deeper wells will be sampled annually. The observation wells have been installed.

2. Component:
   The influence of macropores and soil cracks on the preferential flow of water and chemicals is to be studied in the laboratory and field. Much of the research will focus on better understanding the processes affecting the formation of macropores and soil cracks. Techniques to be used include dyes and helium gas flux. Grid lysimeters also could be used to obtain detailed information on seasonal pathways and cycles of pesticide adsorption, movement, and persistence. A final decision on the placement of grid lysimeters in the field has not been made.

   Pesticide degradation associated with row cropping and proximity to crop roots is to be studied in the laboratory and field using $^{14}C$-labeled herbicide compounds.

   Herbicide persistence cells placed at various depths in the soil profile to the depth of rooting are to be used to monitor changes in herbicide persistence as a function of depth in the soil profile. Herbicide persistence is to be related to soil moisture, temperature, and chemical characteristics, and the microbial communities present at each depth. A final decision on the placement or use of the herbicide persistence cells in the field has not been made.

   Nitrogen and oxygen isotopes are to be used to determine the quantity of nitrate from fertilizers in ground and soil waters in clay-rich materials. Existing isotopic signatures and fertilizer spiked with $^{15}N$ are to be used to trace nitrogen fertilizers in the soil and ground waters. Samples of runoff, soil water, rainfall, and ground water are to be analyzed for $^{15}N$ and $^{18}O$ to trace the fertilizer. Changes in isotopic signatures are expected to reveal the extent of nitrification and denitrification. New laboratory methods are to be developed and tested for the determination of $^{18}O$ in nitrate and to significantly decrease the cost of $^{15}N$ analyses, making $^{15}N$ analyses an affordable tool in nitrogen studies. The component research is being conducted by USGS scientists in an area adjacent to the field area and research plots of MSEA Site #1.

   Transpiration along the flow system and by riparian vegetation near the discharge zone is an important component of ground water discharge. Water level recorders are to be used to examine transpiration-induced diurnal water table fluctuations. Instrumentation is to be installed in Goodwater Creek to determine if the ground water discharging into the creek has lower concentrations of dissolved chemicals than do wells located upslope of the riparian zones. The instrumentation has not been installed.

3. Scale:
   Precipitation and climatic variables from a Class A weather station is to be measured within the 6,730-hectare MSEA Site #1. The spatial distribution of rainfall is to be measured over the watershed using recording rain gauges. The weather station is operational.

The 2,330-, 3,370-, and 6,730-hectare watersheds are instrumented with a weir and water stage recorder. Each weir is to be instrumented with a refrigerated pumping sampler to measure chemical concentrations and losses on an event basis. This instrumentation is being purchased and will be installed by USGS in CY91.

The main tool for aggregation is mathematical modeling. Scale studies involving surface water will include models such as AGNPS. Preliminary assessments have been made on the use of AGNPS to evaluate surface water quality in the Goodwater Creek watershed.

Economic and environmental assessments will be made to determine the potential economic and water quality effects of employing Farming Systems 2 and 3 throughout the Goodwater Creek watershed. These assessments will entail integration of mathematical optimization models, physical process models, geographic information systems, and detailed farm surveys. A more complete assessment of water quality can be achieved by testing the water quality in a sample of domestic wells located in the watershed. Such water well tests would complement the surface water quality sampling being conducted in Goodwater Creek.

4. Modeling:

Several mathematical models are to be examined to identify the processes they represent and the strong and weak points of each. New knowledge gained from component research is to be incorporated into key models to improve their prediction accuracy. Examples include macropore and crack formation induced by wetting and drying, freezing and thawing, and root proliferation within the soil. Hydrologic component is to be modified to represent the influence of interflow over the claypan as well as the influence of saturated soil on chemical fate and transport. Initial plans have been initiated but specific modeling strategies or approaches were not presented.

The physical and chemical data sets are to be used to validate model predictions against measured variables and to evaluate the effect of modifying the models to better represent existing processes or to represent new processes. Data needs for the various models have not been fully assessed.

A chance-constrained programming model is to be used to identify farming systems that maximize net farm income subject to a limit on the probability of exceeding a specified level of surface and/or ground water pollution.

Model applications are to be facilitated by the development and use of Geographic Information Systems (GIS) interfaces. Specific Plan for the use of GIS was not presented.

5. Prescription Farming:

Spatial variability of soil properties and grain yields are to be quantified and analyzed to allow the application of site-specific technologies.

Measurement and control systems and components are to be developed and subjected to engineering performance tests in the laboratory. Once performance characteristics are documented and optimized, systems are to be integrated for field evaluation, primarily at the field level. Detailed plans for conducting the prescription farming research at the MSEA field sites are being developed.

6. Socioeconomics:

Sociological surveys will be used to identify and evaluate current cropping systems and uses of agricultural chemicals, farmers' attitudes and behaviors regarding pollution of ground water by agricultural pesticides and fertilizers and the use of alternative farming systems, and personal and social facilitators/barriers to the adoption of farming systems to improve water quality. An initial survey of farm operators in the Goodwater Creek area has been conducted and initial evaluations have been completed.

Research methodologies will be combined with modeling tools and survey information for farmers in and outside the Goodwater Creek watershed to assess adoption behaviors of land operators. Specific factors to be examined include existing farming practices, agricultural chemical application rates, criteria used in making decisions regarding adoption of technologies and techniques, attitudes toward ground water problems, perceptions of environmental degradation associated with production agriculture, access to technology transfer systems, personal characteristics of owner-operators, institutional barriers to and facilitators of adoption, and farm enterprise characteristics.

Economic models are to be used to evaluate the profitability of current and alternative farming systems. Cost and return budgets are to be used to estimate net returns for individual farming systems that protect water quality. Preliminary indications are these economic models can be developed.

A mathematical programming model is to be used to evaluate the effects of variation in crop yields, crop prices, and farm and resource conservation policies on the efficient choice of farming systems. Of particular interest are policies that enhance planting flexibility by not penalizing farmers for using crop rotations and less chemical intensive farming practices, and policies that restrict the use of agricultural chemicals. Investigators are encouraged to coordinate with the Economic Research Service in developing policy scenarios to be used in the analysis.

7. Education:
University of Missouri extension, with its educational resources and academic expertise, will transfer economic and environmental information gained from MSEA research activities to farmers, extension specialists, soil conservationists, and legislators. The information will be used to promote better understanding of water quality concerns and issues. An extension component is already underway at the Missouri MSEA location.

The MSEA extension education coordinator plans to work closely with MSEA project managers, scientists, and staff to enhance understanding of MSEA project research findings. Efforts also will be made to collaborate with county, state, and federal agencies to disseminate MSEA research results, as well as to coordinate water quality education and information activities. Dissemination is to be through workshops, conferences, demonstrations, and newsletters. The MSEA extension coordinator should continue to play a major role in the planning and assessment of the progress being made at the Missouri MSEA location. The newsletter and quarterly report are valuable tools in communicating the progress.

Database Design and Exchange

Database management for the Missouri MSEA project will be provided through the use of Omnis 5. The multi-user, multi-platform database system will operate across both Macintosh and IBM compatible personal computer systems. The proposed system should provide an extremely wide variety of access methods, reporting capabilities, and import/export formats to provide maximum use of the collected data. The review team commends the Missouri MSEA on their selection of the Omnis 5 system and encourages development of standard operating procedures for all data elements to be measured.

Analytical Tools

The review panel was told that most experimental research on alternative cropping systems in Missouri has focused on soil fertility. Knowledge is limited concerning how specific farming systems affect surface and ground water quality and the processes governing the movement of nitrogen and pesticides to ground water in claypan soils. The Missouri MSEA project will improve the knowledge base needed to design farming systems, educational programs, and public policies for reducing agricultural contamination of surface and ground waters. Extensive information is

available on the geology, soils, and weather and climate of the Goodwater Creek watershed. Little information is available on the hydrology and the movement of water along with the fate and transport processes for claypan soils. Models appear to be appropriate means for refining existing technologies to include soil cracking, preferential flow, and lateral flow components.

Quality Assurance/Quality Control

The Missouri MSEA has developed initial plans and protocols for the personnel and scientific project management of QA/QC. A manual of Standard Operating Procedures has been developed along with a coding system for data collection. The data collection coding system was not made available to the review team as indications were that this system has not been fully initiated at this time. Also, the laboratory and field personnel need to be provided appropriate protocols for sample collection, identification and analyses.

Management Organization

The Missouri MSEA organization consists of administrative, project, and research teams. The research teams are divided among the various project objectives and tasks to be accomplished. A clear understanding of management responsibilities was not evident to the review panel. Investigators are encouraged to develop a detailed project plan with management and research responsibilities clearly defined.

Technology Transfer Plans

Detailed education and technology transfer plans were not presented to the review panel. General extension education activities include formation of a MSEA education committee, regular interaction with MSEA project team, working closely with extension field personnel, and cooperating with other federal and state agencies on water quality issues. The extension coordinator participates in the development of the MSEA project plans and operations as well as provide MSEA project literature, a quarterly newsletter, contacts with mass media, etc.

Interagency Linkages

Cooperative efforts among ARS, University of Missouri, USGS, University of Missouri Extension, and SCS personnel appear to be improving. In particular, we commend the researchers for holding Missouri MSEA meetings every two weeks. These meetings for planning and progress reporting should continue to increase integration of the component research with the research underway in the field and research plot areas. The co-PIs need to initiate a management plan that assigns responsibilities with frequent checks on accomplishments to assure interagency linkages.

Anticipated Results/Time Frame (Products)

Products listed in the MSEA program plan document appear to be adequate. However, it is questionable whether these products can be delivered over the next four years. Over 30 papers are anticipated from the Missouri MSEA project. The following is a summary of the expected products for the seven project objectives.

1. Assessment:
   Products will include new knowledge and information on how alternative farming systems affect surface runoff and erosion, chemical transport and fate within the root, vadose, and ground water zones, and farmer/landowner perceptions of economic and water quality benefits of the farming systems. The databases will be useful to MSEA and other state and federal personnel to better understand the effects and interactions of climate, soil, topography, geology, and cropping and management practices on the variables measured in this phase of the research. Measured variables will also be useful in validating a number of natural resource models, particularly those that predict the movement of agricultural chemicals in the

environment. This information will be used to produce bulletins and guides for use by conservation and extension personnel to educate farmers and the general public, and technical journal publications to distribute findings to other scientists.

2. Component:
This research will focus on mechanisms and processes responsible for chemical fate and transport in the environment, which will result in technical journal publications for use by the scientific community. Other products will be theoretical, empirical, and statistical equations that will be used to improve a number of natural resource research and user models. Component research results will add to the general understanding of agricultural chemical and alternative farming systems impacts, and this knowledge will be incorporated into the bulletins and technical guides for use by state and federal agency personnel, farmers, and the general public.

3. Scale:
Results from scale research will be useful to state and federal personnel in determining how changes in farming systems will impact surface runoff, subsurface flow, erosion, chemical movement within a project area, as well as farm production and income. Data obtained from this research will be used to help develop mathematical models that can be applied to project-size areas.

4. Modeling:
Products originating from modeling research will include mechanistic, stochastic, and statistical equations and models that should improve existing equations and instruments. Because of the complexity of the claypan soils and the influence of the clay layer on physical, chemical, and biological processes, many of the equations and models will be used to describe the influence of the claypan on processes that affect chemical transport and fate. These products will take the form of verified and validated equations, subroutines, and models and accompanying documentation. Other expected products will include procedures to integrate GIS data to replace input files normally read into a model to provide soil, topography, and cropping and management data. Other equations and models will be developed to better predict the influence of farming systems on social and economic variables important to the adoption of alternative farming systems.

5. Prescription:
New engineered systems for site-specific farming and knowledge required to implement these systems will be developed. Emphasis will be placed on technology which appears promising for eventual use in production agriculture. Efforts will be made to transfer this technology for commercialization where appropriate.

6. Socioeconomics:
The socioeconomic component of the project will focus on developing products that enhance the social acceptability and economic profitability of alternative farming systems, and ultimately the likelihood that farmers will adopt alternative farming systems.

7. Education:
The education component of the project will focus on transferring research findings to farmers, extension specialists, soil conservationists, legislators, and the general public.

<u>Likelihood of Attaining Objectives</u>

The likelihood of attaining the objectives of the project can be enhanced by developing: a) a detailed research plan that states the research hypotheses to be tested; and b) milestones for the completion of tasks that are essential to the achievement of research objectives. Within the Assessment objective, greater attention needs to be given to the effects of the three farming systems on surface and ground water quality. Specifically, greater emphasis should be given to the effects of farming

systems on a glacial till aquifer overlain near the surface by a dense claypan and the processes involved in the movement of water and chemicals laterally and through the claypan.

Transferability, Scale Up, Regionality Potential

The project objectives on socioeconomics and education appear to be well planned and directed. The socioeconomic surveys have been coordinated with the Ohio MSEA; however, the Iowa, Minnesota, and Nebraska MSEA surveys should be more closely linked to the initial and future socioeconomic evaluations underway at Missouri. Improvement in the understanding of the potential water quality problems in the Goodwater Creek watershed would help to improve the transferability, scale up, and regional potential for the socioeconomic and educational efforts.

## Recommendations

The MSEA Study

1. The Missouri MSEA should pay close attention to those aspects of the experimental plan that can be reasonably implemented to minimize the possibility of cross contamination of agrichemicals among the plots. For example, plot borders should extend well into the claypan to eliminate water and chemical movement moving in lateral flow over the claypan surface. The review team also recommends that ground water flow paths within the research plot area be measured using a closely grided and monitored piezometer network.
2. Preliminary models on crack development and water and chemical interflow should be identified and studied to evaluate how the processes are being represented. This information will be useful in formulating specific plans for adding these processes to models used by action agencies to assess the influence of farming systems on water quantity and quality.
3. Sixteen existing wells within the Goodwater Creek watershed are scheduled to be sampled and a water quality analysis performed. Consideration should be given to analyzing the age of the water in the sampled wells.
4. Laboratory and field personnel need to be provided appropriate protocols for sample collection, identification, and analysis.
5. The Extension Specialist is encouraged to participate in the development of the MSEA project plans and operations.
6. The Missouri MSEA needs to prepare a written project management plan. The plan should designate the person(s) responsible for each research/education objective(s) and the milestones that need to be achieved for successful completion of each objective. The plan should be operational by March 1, 1992.

MSEA Management Team, Research Committee, Agencies

1. The MSEA Management Team needs to work closely with the co-PIs in the development of a research and data collection plan that integrates the assessment and component research studies into achievable objectives. The Management Team needs to determine if the component research is focusing on the water quality problems for claypan soils.
2. The Research and Development Committee of the USDA Working Group on Water Quality needs to work with the MSEA Management Team and Missouri MSEA project to assess the hydrologic system and fate and transport of agricultural chemicals for claypan soils. Consultants with expertise in flow through claypan soils may be needed.
3. ARS and CSRS need to assure that appropriate emphasis is being placed on management of the MSEA study; USGS needs to become more actively involved in conducting and advising on assessment and component research being conducted within the field areas and research plots; and EPA needs to become more involved in determining if adequate surface water quality measurements are being taken to assess ecological impacts.

## NEBRASKA

## Assessment

### Nebraska Management Team

| Name and Responsibility | Title and Affiliation | Area of Expertise |
|---|---|---|
| J. S. Schepers, co-PI<br>Management systems | Soil Scientist-USDA/ARS | Soil Chem, N mgt/utilizn |
| R. Spalding, co-PI<br>Quality assurance | Associate Dir, Univ of NE Water Center, Professor, Agronomy | Hydrochemistry |
| D. G. Watts. co-PI<br>Tech transfer | Professor, Biological Systems Engr | Water management, quality |
| D. L. Martin<br>Models, decision aids | Assoc Professor, Biol Systems Engr | Irrig, water resource engr |
| R. J. Supalla<br>Socioeconomics | Professor, Agricultural Economics | Water resource economics |
| D. B. Marx<br>Data management | Professor and Head, Biometry | Geostatistics |

### Project Goal

The goal of the Nebraska MSEA project is to develop and evaluate cropping systems and farming practices to reduce ground water contamination (primarily nitrate) while providing profitable management alternatives to farmers.

### Background Information

The principal MSEA project site is in Nebraska's Central Platte Valley, a region where more than 90 percent of the land is under cultivation. Over 75 percent of the cropland is devoted to the continuous production of irrigated corn and about 10 percent to irrigated soybeans. Serious ground water contamination problems are being experienced in the area as indicated by the ever-increasing number of municipal wells exceeding acceptable nitrate levels. Within the region, over 200,000 hectares between the cities of Kearney and Columbus in the Platte Valley are underlain by ground water having nitrate-nitrogen levels greater than U.S. Public Health Service standards. The contaminated area is expanding by more than 4,000 hectares per year.

The increased risk of ground water contamination associated with irrigation necessitates special pesticide, nitrogen, and water management considerations. While the production systems demonstrated and management practices researched in the Nebraska-Kansas MSEA project will emphasize irrigated cropping systems, the management strategies involved will apply throughout the region. Availability of irrigation in Nebraska and other North Central States provides an opportunity to respond to crop nutrient needs via fertigation. (Fertigation is the practice of applying commercial fertilizer through an irrigation system.) Technologies developed in the Nebraska MSEA project for assessing crop nitrogen status will apply throughout the region and can be used in conjunction with furrow or sprinkler irrigation practices.

### Site Description

The project site near Shelton, Nebraska is located on the river terrace about 4 kilometers north of the Platte River. The site consists of four 16-hectare "management blocks" and a 32-hectare field for component research under both sprinkler and furrow irrigation. A 64-hectare buffer area separates the management blocks and the component research area.

Geology. The principal aquifer in the area consists of shallow Quaternary fluvial silt, sand, and sand and gravel deposits that are 15 to 18 m thick. The Quaternary deposits are underlain by a 6- to 12-meter thick clayey siltstone that is characteristic of the upper part of the Ogallala Formation (Miocene) in this part of Nebraska. This clay siltstone probably acts as a partially confining layer to the more permeable deposits in the lower part of the Ogallala. The lower part of the Ogallala generally ranges between 12 and 18 meters in thickness and consists of interbedded silts, poorly consolidated sandstones, and thin gravel beds.

Soil Description. The predominant soil at the site is a Hord silt loam with small areas of Hall and Wood River silt loams and Blendon loam. The Hord soils have a thicker, more friable and less clayey B horizon than the Wood River soils, and a more friable and less clayey $B_2$ horizon than the Hall soils. Hord soils have a finer textured B horizon than the Blendon soils. All soils at the site are underlain by sand at a depth of 120-150 cm.

Weather and Climate. Long-term weather records from a Class A station are available from Grand Island, Nebraska, some 40 kilometers east of the MSEA site. Similar data are available at the Kearney station about 35 kilometers to the west. In addition, a fully automated station providing hourly averages of wind speed and direction, temperature, relative humidity, solar radiation, and soil temperature has been located 11 kilometers from the MSEA site since 1980. An automatic recording station will be installed at the site. Five recording rain gauges will be placed equidistant across the demonstration and research blocks.

Agrichemical leaching is strongly influenced by percolation amounts, which are dependent on soil type and both chemical and irrigation management. Annual precipitation at the MSEA site averages 61 cm with 42 cm falling during the May through September growing season. Evapotranspiration during the same period is 60-70 cm. Seasonal irrigation amounts typically range from 43 cm on the silt loams to 135 cm on sandy soils, while net irrigation requirements average 28 cm and 38 cm, respectively. As a result, in-season deep percolation ranges from 15 to over 100 cm, depending on soil type and irrigation method. Off-season percolation amounts typically range from 5 to 15 cm.

Hydrology. Ground water flow is east-northeast. The Platte River is a losing stream in this area, and during periods of high flows (spring and early summer) supplies recharge to the adjacent shallow aquifer. Depth to ground water across the MSEA site ranges from 4.5 to 5.7 meters. During dry years in the late 1970's, the depths to ground water were about 1 meter greater.

A 1974 ground water quality survey revealed that the $NO_3$-N levels within the area around the MSEA site averaged 18 mg/L. Nitrogen isotopic studies indicate that most of this is from agronomic sources and not animal or human wastes. Atrazine and alachlor also have been detected in the ground water in the immediate vicinity of Shelton. Atrazine levels ranged from below detection to 3.1 ug/l in the ground water beneath the terrace, and from below detection to 88 ug/l in the bottomland ground water.

The loading of inorganic and organic chemicals into the aquifer was estimated from data from nested monitoring wells installed in a 4,000-hectare area, 2.4 kilometers south of Shelton in 1977 and the Platte River. Elevated nitrate, dissolved organic carbon, and atrazine levels occurred in shallow wells downgradient from irrigated fields and were vertically stratified within the primary aquifer. Stratification reflected recent loading, with the highest concentrations in the shallowest wells. A later study reported $NO_3$-N levels exceeded 100 mg/l in some shallow monitoring wells between the towns of Shelton and Wood River.

Current farm management systems. The previous system at the MSEA site is similar to the entire Central Platte Valley. It is dominated by irrigated corn production with an occasional rotation into soybeans. Irrigation water at the site is supplied by one well per 16 to 32-hectare field. Well capacities range from 50 to 75 l/s. Furrow irrigation is used. Normally, every row is watered on

a 12-hour set. Runoff is typically controlled by diking the end of the field so that all runoff soaks into the ground within the field. Water may collect for a distance of 90 meters or more in the field behind a dike.

There is little runoff from these farms due to precipitation prior to the irrigation season. The flat slopes (less than 0.1 percent gradient) and internal system of field roads and dikes hold runoff on the field. This approach to runoff management for both irrigation and precipitation contributes significantly to the potential for leaching of agrichemicals, and $NO_3$-N in particular.

In the absence of significant rainfall, irrigation water is applied weekly. The first irrigation of the season (usually in early July) is the highest application, with typical amounts ranging from 15-20 cm. Subsequent irrigations are on the order of 10 cm.

Project Objectives

1. Compare the net effects on ground water quality of conventional and alternative management systems for irrigated crop production;
2. Increase the knowledge of fate and transport of agricultural chemicals under conventional and improved irrigated production systems;
3. Develop and evaluate new technologies for management of pesticides, nitrogen and irrigation to reduce ground water contamination;
4. Develop models and decision-making systems to aid farmers in choosing management strategies that are both environmentally sound and profitable;
5. Identify and analyze the social and economic factors that influence the acceptability and implementation of management options for improving water quality.
6. Evaluate farm level impacts and estimate regional economic impacts of alternative agricultural management practices to improve water quality.

The project objectives are appropriate. Strengths include evaluation of N fertilizer and irrigation management strategies under conventional and improved production systems. An additional objective to include measures necessary to achieve a nitrogen balance would enhance the project.

Major Hypotheses

The researchers indicated that major hypotheses will be developed for various research projects. These hypotheses will be provided in a Nebraska MSEA project manual scheduled for completion in early 1992.

Experimental Design

The design for the core experiment is good. An estimate or measure of water and $NO_3$ flux leaving the crop root zone is needed. The review team recommends initiation of tracer studies on the large management blocks to estimate the movement of water and agricultural chemicals in the root and vadose zones. There also is some question whether a change in ground water $NO_3$ concentration will be detectable within the time period of the project.

The review team recognizes that the multi-level sampling wells may provide a direct evaluation of the impact of the field farming systems on ground water quality over time. Hopefully, the tracer studies can be correlated with the ground water quality measurements.

The following is a brief description of the experimental design which will focus on (1) field farming systems, (2) ground water monitoring and assessment, (3) component research to extend knowledge of fate and transport of agricultural chemicals, and (4) socioeconomic factors related to adoption of alternative management strategies.

Field Farming Systems. Research on three of the management blocks at the principal site will concentrate on the evaluation and demonstration of available technology packages for water, nitrate, and pesticide management on irrigated, monoculture corn. All fields planted to corn receive a small application of starter fertilizer and banded atrazine at planting., A fourth flock will concentrate on using alfalfa as a nitrogen scavenger crop. The four management blocks are:

- Current farmer practice.
- BMPs with surface irrigation.
- BMPs with sprinkler irrigation.
- Sprinkler-irrigated alfalfa.

The current practice block is to receive a preplant application (only) of $NH_3$ without nitrification inhibitor with atrazine banded at planting for weed control with conventional furrow irrigation with 12-hour continuous sets and end-of- field diking in lieu of tailwater recovery. The fertilizer nitrogen amount is estimated according to guidelines that include defining a reasonable yield goal and accounting for both residual nitrate in the soil and the nitrate content in the irrigation water.

The BMP surface irrigation block has received laser-guided, land grading and will receive alternate row surge irrigation, tailwater recovery, and irrigation scheduling according to crop water use. (Surge irrigation is the intermittent application of irrigation water with a series of on-off cycles to the field. Tailwater recovery is the reuse of the runoff water from a sloping irrigation field for part of the irrigation water supply.) The preplant $NH_3$ application is applied with a nitrification inhibitor, while sidedressed fertilizer will not receive an inhibitor. Fertilizer application amounts are reduced below current guidelines to account for nitrogen mineralization and nitrogen applied from the irrigation water through the growing season. After proposed furrow irrigation fertigation techniques are perfected, seasonal nitrogen application may be split, with part being applied in the irrigation water.

The BMP sprinkler irrigation block is served by a center pivot system with a corner unit. Irrigations are scheduled according to measured crop water use. A soil water deficit is maintained to provide for storage of rainfall. Nitrogen applications are scheduled based on frequent lead sampling with a chlorophyll meter to permit full utilization of all possible N sources.

Ground Water Monitoring. Because of lateral ground water movement beneath the MSEA site, a uniformly managed "buffer zone" has been established on the up-gradient side of the 16 ha blocks to ensure an inflow of shallow ground water of relatively good quality. The high background levels of agrichemical contaminants in the ground water at the MSEA site will make it difficult to monitor changes in ground water contaminant levels resulting from BMP application on the overlying soils. Success will depend on management of the up-gradient buffer zone to minimize nitrate and atrazine loading from the crop root zone in that area.

Due to the suspected high amount of agrichemical contamination, the monitoring installation will be phased. During 1990, several multi-level piezometers were installed. The resulting hydraulic head data were used to define the localized water table and both the areal and vertical flow at the site. Samples were collected at various depths below the water table and analyzed. In 1991, multi-level samplers were installed. Each site is instrumented with eight dedicated, multi-level samplers.

The Nebraska District of the U.S. Geological Survey, through the Midcontinent Herbicide Initiative, has characterized the hydrogeologic system in the vicinity of the Nebraska MSEA site. This study provides a general definition of the hydrogeologic framework and the quantification of the movement of water into, through, and out of the ground water system. The U.S. Geological Survey is developing techniques for continuous indirect monitoring of nitrate concentrations in the top few centimeters of the saturated zone. Indications are that this work will be supplemented by deep soil coring conducted under the EPA nonpoint research program through the Nebraska Department of Environmental Control.

Component Research. While work is in progress on BMP package evaluation on the management blocks, associated research will be conducted to develop new practices or improve components of existing ones. Two 16-ha blocks will be established for plot research adjacent to the MSEA management blocks, one under sprinkler irrigation and one under furrow irrigation. Intensive studies will be conducted in four of the five-year MSEA program.

Associated research on BMP development and evaluation of management systems will also be conducted at five satellite locations: (1) ARS Central Platte Valley site; (2) sludge injection site, Grand Island, Nebraska; (3) South Central Research and Extension Center (SCREC), Clay Center, Nebraska; (4) West Central Research and Extension Center (WCREC), North Platte, Nebraska; and (5) Kansas State University Research Farms, Manhattan and Scandia, Kansas.

Socioeconomic Research. Three components of the socioeconomic analysis (Farm level economic effects, regional economic effects, and sociological assessment) will provide policy makers with essential information for balancing potential trade-offs between water quality improvements and the socioeconomic effects at the farm, regional and national levels. This assessment will summarize the trade-offs between water quality improvements and the socioeconomic consequences at both the farm and the regional level. The socioeconomic research has been coordinated with the Ohio MSEA, but details of a socioeconomic survey and assessment plan were not provided. The water quality impacts associated with this comprehensive assessment will be provided from other study components.

Data Collection

An organized plan for statistical analyses and data management and collection was not presented for the three management blocks and key component research. However, most of the data collection equipment has been installed and data collection will be fully covered in a MSEA project manual to be completed in early 1992. Soil and water sampling and analyses are following written protocols common to federal agencies.

The principal investigators have outstanding capabilities and experience in the area of nitrogen management and irrigation. In addition to specialists in soil chemistry, nitrogen management, and irrigation management, the Nebraska MSEA team includes a crop physiologist, soil microbiologist, forage specialists, agronomist with extensive experience in legume and forage crops, agricultural economist, and a rural sociologist. The investigation team needs to meet on a regular basis to define the necessary data to collect and proceed with comprehensive data analyses.

Database Design and Exchange

The plan for database design and exchange apparently had not been established. Investigators are encouraged to develop a database which will permit exchange of data across the region.

Analytical Tools

Installation of irrigation management systems, multi-level water sampling systems, and extensive soil sampling provides a sound base of analytical tools for the program. Addition of a tracer study on the three management blocks to better characterize water, nitrate, and pesticide movement in the crop root and vadose zones would enhance the Nebraska MSEA project.

Quality Assurance/ Quality Control

The QA/QC program is sufficient for the Nebraska MSEA project.

Management Organization

There is strong leadership in the three co-PI's; and there is good budget management since the funds are managed by the Water Center, an interdepartmental entity. The co-PI's could be included in a more precise manner in the organization, design, and planning of the Nebraska MSEA site. However, the investigators are experienced and enthusiastic about the Nebraska MSEA program. Involvement of producers in the program is excellent.

Technology Transfer Plans

Opportunities for increased technology transfer activities are good, including farmer involvement and a newly-hired extension person dedicated to the project. Interaction with crop consultants provides an excellent outlet for any new technology that is developed. Seminars, crop improvement meetings and media programs are assisting in transfer of new technology. The support system for conducting tours at the site is excellent, as is project publicity, including the brochure and hat. Decision aid packages for extension specialists, consultants, SCS and others need to be developed.

The new extension specialist is scheduled to start soon. The plan to conduct demonstrations and evaluations at the project site and then develop educational materials and conduct workshops throughout the district and across the State is excellent. This will allow the extension specialist to be more effective than just serving as a project technician to support site needs. The extension specialist can use the MSEA project as a basis for developing an educational outreach program that can greatly facilitate interdisciplinary and cooperative water quality programming throughout the State.

The initial publicity/education program has served to gain good recognition and support for the project. The enthusiastic endorsement and participation of farmers in conducting this research is outstanding and will greatly facilitate acceptance of results and technology transfer.

Interagency Linkages

Linkages between the University of Nebraska, ARS, Natural Resource Districts, USGS, SCS and EPA are strong and growing.

Anticipated Results/Time Frame (Products)

Prospects are good for meaningful results. A direct measure of $NO_3$ and water leaving the soil profile is needed since other components of the N cycle are being measured. The list of anticipated research products including scientific publications is impressive. The timeframe for preparing the manuscripts for publication is reasonable. The following is a short list of useful products expected from the research effort.

1. A ranking of environmental effectiveness of various joint management strategies for water, nitrogen, and pesticides. Users will be farmers, Extension agents, resource districts, regulatory agencies, and irrigation equipment dealers.
2. A combined ranking of strategies based on both economic and environmental factors. Users will be farmers, Extension agents, resource districts, regulatory agencies, and irrigation equipment dealers.
3. An extensive set of vadose and ground water data describing transport of agrichemicals that can be used in designing improved practices and in technology transfer. Users will be researchers, Extension agents, resource districts, and regulatory agents.
4. Techniques to strategically place nitrogen and irrigation water, reducing the risk of nitrate leaching. Users will be farmers and Extension agents.

5. Fast and reliable tissue analysis techniques to evaluate crop N status and develop N management practices involving fertigation. Users will be agricultural consultants, farmers, Extension agents, fertilizer dealers, and researchers.
6. Fertigation technology to provide acceptable N distribution with furrow irrigation using surge technology. Users will be farmers, Extension agents, and fertilizer dealers.
7. Innovative cropping systems using scavenger and cover crops to minimize nitrate leaching. Users will be farmers and Extension agents.
8. Innovative sensing devices and advanced programming packages to improve operation of surge and conventional surface irrigation systems and to reduce irrigation amounts and improve water distribution. Users will be farmers, resource districts, Extension agents, and irrigation equipment dealers.
9. Improved understanding of N and pesticide movement in soil and vadose zone. Users will be researchers and regulatory agencies.
10. Innovative advances in instrumenting and sampling the vadose zone and ground water. Users will be researchers, resource districts, and regulatory agencies.
11. Predictive models for unsaturated and saturated transport that fit conditions in Nebraska. Users will be researchers, resource districts, and regulatory agencies.

Likelihood of Attaining Objectives

The likelihood of attaining objectives is quite good except for a direct measure of $NO_3$ leaving the soil profile. The modeling effort needs to identify specific models to be tested and develop a plan for collecting the needed input data.

Transferability/Scale up/ Regionality Potential

Transferability of results to the Nebraska-Kansas project area is good since the main experiment is on 16-hectare plots. The investigators were encouraged to consider how the research results could be applied to similar areas across the region. Other irrigated areas have shallow and highly permeable soils overlying aquifers which supply water for agriculture, livestock and people. Some regional comparisons could be made among the Nebraska and Minnesota MSEA sites.

## Recommendations

The MSEA Study

1. The Nebraska MSEA should consider adding a project objective on the evaluation of agriculture chemical mass balance (nitrate and atrazine) for the conventional and improved farm management systems.
2. Although not available at the review, a detailed work plan is being developed and will be available in early 1992.
3. As part of the Nebraska MSEA work plan, the database design and exchange plan needs to be coordinated with other MSEA projects.
4. Cooperation and coordination between the federal and state agencies involved in the project is good and continues to grow.

MSEA Management Team, Research Committee, Agencies

1. The MSEA Management Team needs to encourage regional data exchange and use of data for the development of models that extend results within the state or region.
2. The Research and Development Committee of the USDA Working Group on Water Quality needs to encourage greater involvement with SCS and the Regional Extension Coordinator in developing educational materials and technology transfer plans for the Nebraska MSEA project.

# OHIO

## Assessment

### Principal Investigators

| Name | Title and Affiliation | Area of Expertise |
|---|---|---|
| A. D. Ward, co-PI | Assoc Prof, Agric Engr, Ohio State Univ | Hydrology |
| N. R. Fausey, co-PI | Soil Scientist, ARS, Columbus, OH | Soil physics |
| E. S. Bair | Asst. Prof., Ohio State University | Hydrogeological |
| S. R. Workman | Agricultural Engineer, ARS, Columbus | Unsat flow modeling |
| T. J. Logan | Professor, Ohio State University | Soil/water chemistry |
| S. M. Hindal co-PI | District Chief, US Geological Survey | Water resources |
| S. E. Nokes | Agricultural Engineer, Ohio State Univ | Plant modeling |
| M. L. Jagucki | Hydrologist, US Geological Survey | Hydrogeology |

### Project Goal

The long-term goal of the Ohio MSEA project is consistent with the goal of the overall MSEA program: to evaluate effects of agricultural management systems on water quality in the Midwest.

### Site Description

The Ohio MSEA site is located on the 650-acre farm south of Piketon, Ohio, overlying the Scioto River Buried Valley Aquifer. Buried valley aquifers are typically shallow, permeable, and unconfined, with high recharge rates. They are vulnerable to surface contamination because short flow paths to the water table decrease the potential for adsorption, chemical reactions between contaminants and minerals in the soil, and biodegradation. Approximately 75 percent of the ground water pumped in Ohio is from buried valley aquifers.

Soils overlying the alluvial aquifers are well drained and highly productive. With the increased use of fertilizers and pesticides to maintain high agricultural yields during the 1980's, potential adverse water quality impacts have increased on these soils. A recent study tested over 16,000 private wells in 76 of Ohio's 88 counties for concentrations of nitrate-nitrogen. Although Pike County (site of the Ohio MSEA) was not included in the study, the adjacent counties had elevated average nitrate concentrations.

### Project Objectives

1. To characterize the baseline hydrogeologic, geochemical, and geomicrobial environments of the buried river valley aquifer at the Ohio MSEA and in the Piketon region, and each of the research plots.
2. To assess the effects of the different farming systems on the ecological, hydrogeologic, geochemical, and geomicrobial environment of each system.
3. To determine the dynamic and spatial leaching fluxes of applied pesticides and nitrate under different agricultural management systems.
4. To determine crop production responses to the different agricultural management systems.
5. To determine expected profitability and variability of profits for each commodity under each alternative agricultural system.
6. To identify areas in the region where the most promising alternative agricultural systems could be adopted and then make assessments of the likely benefits of these systems in those locations.
7. To determine socioeconomic factors affecting the adoption of alternative agricultural management systems.

8. To develop practical predictive models and decision support systems for projecting site specific water quality impacts, production levels, and profitability.
9. To augment existing agricultural databases related to water quality.
10. To disseminate MSEA research results and provide technical assistance to farmers implementing new farm management systems.

Major Hypotheses

The Ohio MSEA has identified 10 hypotheses and recommended these to the Regional Data Management Subcommittee:

1. Above ground biomass does not differ significantly between management systems.
2. a. There is no significant difference in above ground biomass N between management systems.
   b. There is no significant difference in output of N from the three crop management systems.
3. Losses by surface runoff are not significantly different among the three management systems in terms of (a) soil; (b) nitrate; (c) pesticides.
4. Root biomass and root biomass distributions are not significantly different between management systems.
5. Soil physical properties, quantity of macropores, and numbers of microorganisms are not affected by management practices: (a) in the root zone and (b) below the root zone.
6. Water content and distribution in the unsaturated zone is not significantly different between management systems.
7. There are no significant differences among the management systems in the concentrations of nitrate and pesticide residues collected in the unsaturated zone: (a) in the root zone and (b) below the root zone.
8. There are no significant differences in the amounts of nitrate and pesticides found in the ground water as a result of the three management practices.
9. Economic profitability (whole farm) does not vary among the tested management practices.

Experimental Design

The following three crop management systems will be evaluated:

Continuous corn

| | |
|---|---|
| tillage | chisel plow |
| herbicides | atrazine and alachlor |
| insecticides | fonofos |
| nitrogen | 150 lb/ac |

Corn/soybean sequence

| | |
|---|---|
| tillage | no-till for corn, chisel for soybeans |
| herbicides | atrazine and alachlor for corn<br>alachlor, metribuzin + chlorimoron-ethyl for soybeans |
| insecticides | based on scouting |
| nitrogen | 150 lb/a following soybeans |

Corn/Soybean/Wheat/Winter Cover Crop Sequence

| | |
|---|---|
| tillage | ridge tillage |
| herbicides | banded application |
| insecticides | based on scouting |
| nitrogen | residual N from rye vetch cover crop with manure for corn<br>- rates of manure application will be based on calculated inputs from cover crop and yield goals for corn, additional N as manure for wheat |

In addition to the above chemicals, Accent and Assure will be used to control johnsongrass at the Ohio MSEA. In order to conduct the saturated flow research, each practice will be established on a separate 25-acre field. Space and resource constraints will prevent replicating these large fields. To obtain statistically valid measurements for research other than the saturated flow research, small plot replicates will be maintained adjacent to the 25-acre field.

The small treatment plots have been arranged in a randomized complete block statistical design, and each plot is 1 acre in size with the following crop sequence treatments:

1. Continuous corn.
2. Corn phase of corn/soybean.
3. Soybean phase of corn/soybean.
4. Corn phase of c-s-w/cover.
5. Soybean phase of c-s-w/cover.
6. Wheat/cover phase of c-s-w/cover.

Each plot is bordered by an untreated strip approximately 35 feet wide and planted to a cover crop such as grass. The border strip allows equipment to work the plot, and minimizes overlapping effects of treatments. An area has been set aside (13.5a) for research on alternative practices. This research will have the same statistical design and sampling schedule as the small replicate plots. It should be initiated in 1992 when additional funds are identified.

<u>Data Collection Approach</u>

Eighteen specific research activities are described in detail in Volume 1, "Project Description," for the Ohio MSEA. The following is a summary of the first five activities:

<u>Systems Component I</u>

<u>Economic Evaluation</u>. An extensive list of economic data is being collection, e.g., price received for commodity, seed cost and use, fertilizer cost, machinery requirement for application, herbicide/insecticide cost, labor hours and wage, fuel costs, and a summary of expenses from MSEAs and commercial farms in the region using similar agricultural practices, etc.

<u>Systems Component II</u>

<u>Crop Production System</u>. Two automatic Campbell weather stations have been installed at the Ohio MSEA site. One station is located adjacent to the research plots and the other near the Department of Energy (DOE) wells to the southwest of the plots. A wet/dry collector will be used to obtain composite precipitation samples. Root distributions are to be sampled monthly, beginning with emergence and continuing until harvest. Above-ground biomass will be obtained monthly from three strips of row randomly selected in each plot. Canopy cover will be recorded from a predetermined location in each plot. Pest infestation and plant damage will be quantified using scouting and standard pest management assessment techniques. Surface residue cover will be recorded in the spring and fall in all plots. Final grain yield will be recorded at harvest from each plot.

<u>Systems Components III</u>

<u>Hydrologic Processes</u>. Temporal and spatial changes in the quantity and quality of surface, unsaturated, and saturated water flows will be monitored. Water samples will routinely be analyzed for the following constituents:

<u>Pesticides & Organic Chemistry</u> - total pesticide in water, pesticide metabolites, and dissolved organic carbon.

F<u>ertilizers</u> - nitrate, nitrite (or sum of the two), ammonia, total Kjeldahl N, orthophosphate, TKP, and potassium.

Inorganic Chemistry - pH, conductivity, dissolved oxygen, and suspended solids. On selected samples, the researchers will determine major ions.

Tracers - Bromide and chloride. In addition, USGS and EPA have expressed interest in conducting studies with naturally occurring tracers.

Surface Flow. Surface runoff will only occur on a few occasions during a growing season. It is proposed to locate a small levee (0.2 to 0.5 m high) around a portion of a replicate plot representing each phase of each treatment. These areas will be designed so that runoff will flow into a surface collection system and through a tipping bucket monitoring system. Surface water stage recorders will be installed on the Scioto River, located on the western boundary of the MSEA, and Big Beaver Creek, located on the southern boundary of the MSEA.

Unsaturated Flow. Water content distribution in the unsaturated zone will be monitored on a biweekly basis. Water content data will be collected by a combination of a direct and an indirect technique. These techniques are soil cores, and either a neutron probe or time domain reflectrometry (TDR).

The following methods are planned to monitor chemical movement in the unsaturated zone: (a) soil cores; (b) porous cup suction samplers; and (c) wick samplers. Porous cup and wick samplers are being studied to identify a suitable monitoring scheme. Soil cores will be obtained, handled, and analyzed using regional QA/QC protocols. These cores will be analyzed at the USDA National Soil Tilth Laboratory in Ames, Iowa.

Saturated Flow. The monitoring scheme for the saturated zone is to quantify ground water flow and ground water quality on two scales and is designed to be integrated with the monitoring scheme in the unsaturated zone. The "local or regional scale" monitoring network is designed to collect data at the scale of the farm and adjacent upgradient areas. Thirty-seven wells have been installed at the Ohio MSEA. These include 11 water table wells, 4 bedrock wells, and 22 multiport wells.

Systems Component IV

Establishment of a Regional "Core" Database. The regional "core" database will contain the following elements: 1) a summary text information file which describes the Ohio MSEA and provides contact phone numbers and addresses (1-5 pages); 2) a more detailed technical text information file which provides capsule information on each research activity (20 pages); 3) a site characterization data file; 4) a "core" data file which has been identified by the Regional Data Management Subcommittee, and 5) an annual summary file (text and some data) for each specific research activity.

Systems Component V

Socioeconomics. The purpose of the socioeconomic part of the project is to identify barriers to and facilitators of adoption of soil and water conservation practices at the farm level among farmers in the Scioto River Basin in Ohio. The specific objectives of the proposed project are as follows: 1) to evaluate land operator awareness of and knowledge of recommended farming practices designed to protect water resources from agricultural pollution; 2) to examine the perceptions of land operators relative to how acceptable and feasible it is to implement recommended farming designed to protect water resources from agricultural pollution at the farm level on a voluntary basis; 3) to assess use of recommended farming practices designed to protect water quality in terms of present use, past use, and anticipated use; 4) to assess the extent of use of recommended farming practices designed to protect water quality at the farm level; and 5) to develop statistical models to predict voluntary adoption of recommended farming practices designed to protect water quality at the farm level. Phase one includes personal interviews with approximately 1,000 land operators in Scioto River Basin of Ohio. Land owner-operators are requested to complete an initial structured questionnaire in the presence of a trained interviewer. Data from this initial questionnaire are now being analyzed statistically.

Database Design, Exchange, and Analytical Tools

For the 18 specific research activities listed in Volume 1, "Project Description," database design, exchange, and analytical tools are described for all components. The following is a summary and brief discussion of the first five components.

Systems Component I

Economic Evaluation. Economists are involved by identifying data to be collected in order to allow a complete analysis of the profitability for each system studied. Efforts during the second and third years will be to describe the expected profitability and variability of profits for each enterprise (commodity) within each system. Estimates of the rate of substitution among key inputs (labor, tillage, herbicides, and insecticides) will be made. Research conducted during the fourth and fifth years of the study will focus on development of farm level models of farm profitability. The whole-farm model will be structured to consider this impact on off-farm employment in addition to employment of the other farm resources.

The owner of the Ohio MSEA site, Mr. John Vanmeter, is a willing cooperator who will do an excellent job of providing economic and production data to the researchers. The review team felt that a reasonable comparison of the economic costs and returns could be made for the three farming systems.

Systems Component II

Crop Production. The Ohio MSEA project has identified plans and methods for the measurement of fertilizer, precipitation and crop residue inputs; nitrogen fixation; nitrogen transformations, nitrogen export and losses; denitrification; ammonia fluxes; plant N losses; microbial activity and diversity; soil invertebrates; and insect populations, disease, and plant damage. It would appear that adequate nitrogen cycling information is being collected to model the nitrogen cycling processes. However, the review team was not given details on the measurement of effectiveness in weed control, e.g. johnsongrass, among the three farming systems. After the review, the Ohio executive management group indicated that weed pressures would be quantified three time per year.

Systems Component III

Hydrologic Processes. Ten research activities or projects have been identified under hydrologic processes. These include characterization of soil physical and hydrological properties; microbial and chemical processes affecting the fate of agricultural pesticides in surface and subsurface environments; evaluation of the effects of physical, chemical, and biological factors in pesticide sorption, biotransformation and transport in the buried river valley aquifer; effects of farming practices and soil and aquifer variability on nitrate occurrence in ground water; bias in field sampling techniques for assessing inorganic/organic constituents in ground water; etc.

The Ohio MSEA project should be commended on the emphasis being placed on the assessment and evaluation of hydrologic processes. The Ohio MSEA is planning to evaluate effects of alternative soil and crop management systems on soil physical and hydrological properties, water balance, transport of dissolved and suspended loads in surface runoff, and emission of greenhouse gases from soil-related processes. The fate and transport research is an important aspect of the President's Initiative; however, the characterization of buried valley aquifer water flow systems can be complex. Ground water flow direction and gradients may change as ground water levels in the drift aquifer and water levels in the Scioto River and Big Beaver Creek fluctuate with time.

Systems Component IV

Establishment of a Regional "Core" Database. The database management system, ORACLE, has been chosen as the database for the Ohio project. The Regional Data Management Committee reached a consensus on the general design of the data tables; however, procedures for the maintenance and management of the regional database have not been agreed upon.

Systems Component V

Socioeconomic. The proposed model for the adoption of conservation behaviors by land operators is strongly influenced by characteristics of the farm enterprise, institutional constraints, access to mechanisms to diffuse information and technical assistance, attitudes, and individual characteristics of farm operators. The model stresses that each of these components of the theoretical perspective can act as barriers to and/or facilitators of the adoption of water quality protection practices.

Quality Assurance/ Quality Control

The Ohio MSEA plan in Volume 3, "Field Sampling for Agrichemical Determination and Aquifer Characterization," has a complete listing of procedures used in the collection of field water and soil core samples and the measurement of water levels at the field site. The documentation describes the instruments to be used, the methods of measurement/collection, decontamination procedures, and calibration of instrument methods. Example forms for the field QA/QC records were also provided. A description of the QA/QC for the sampling analysis and types of sample containers, sample identification, etc. are given in Volume 5, "Field Sampling and Specific Activities--Standard Operating Procedures." The review panel was impressed by the fact that field personnel had received training on the QA/QC procedures and field SOPs; and the laboratory personnel were also knowledgeable in the QA/QC procedures and involved in developing and monitoring the field protocols.

Management Organization

The Ohio MSEA plan in Volume 2, "Project Administration and Data Management Guidelines," provides a detailed discussion of the project administration. Management of the Ohio MSEA will be provided by three groups: (a) an Executive Management Group (EMG); (b) a Technical Steering Committee (TSC); and (c) the Ohio Advisory Committee (OAC). The EMG is responsible for the administration of all fiscal and technical aspects of the study. In addition, this group is responsible for all routine data collection activities, data management, and the development of a "core" database. The management organization appears to work together effectively.

Technology Transfer Plans

Technology transfer plans appear to be good. Members of the Ohio Advisory Committee include representatives from industry, special interest groups, environmental groups, and State and federal agencies. This committee reviews project activities and makes recommendations on program directions. Interaction with advisory groups provide opportunities for technology transfer. The Ohio MSEA has hired an extension specialist for the project.

Interagency Linkages

Linkages are excellent among ARS, Ohio State University, and USGS researchers. The Ohio MSEA Team continues to improve interactions with SCS and EPA personnel.

Anticipated Results/Time Frame (Products)

Prospects are good for meaningful results. The list of anticipated research products including scientific publications is impressive. The timeframe for preparing the manuscripts for publication is reasonable. Listed below are examples of end products for the first five activities.

Systems Component I

Economic Evaluation. Economic evaluation of alternative production systems employed in the MSEA projects.

- Estimates of profitability distributions for the farming systems studied in the Ohio MSEA project (testing of Ohio economic hypothesis), Objective 4 Summer 1993 and Fall 1995.
- Whole-farm simulation models of farm profitability will be developed, Objective 4 and 5 - Fall 1995 and Summer 1996.

Crop Production Systems. Biological Processes in Soil Under Selected Farming Systems and Their Impact on Ground Water Quality.

- Quantification of major nitrogen inputs and outputs for the three farming systems, including N fixation, denitrification, volatilization and gaseous losses from plants. Objective 2 - Spring 1992, Spring 1994, and Spring 1996.
- Data on internal nitrogen cycling processes in each of the farming systems, including soil N pools, nitrogen transformations (N mineralization-immobilization and nitrification), and plant uptake of N. Objective 2 - Winter 1994 and Winter 1996.
- Evaluation and refinement of N cycling models used to predict NO3-N production and cycling in soil. Objective 2 - Winter 1994 and Winter 1996.

Systems Component III

Hydrologic Processes. Characterization of Soil Physical and Hydrological Properties.

- Soil water balance for different systems of soil and crop management. Objectives 1 and 2 - Spring 1993 through Fall 2000.
- Research data on magnitude and rate of change of soil physical and hydrological properties in alternative farming systems. Objective 2 - Winter 1995 through Summer 2004.

Systems Component IV

Establishment of a Regional "Core" Database. Microbial and Chemical Processes Affecting the Fate of Agricultural Pesticides in Surface and Subsurface Environments.

- For each pedologic horizon and each geologic stratum, a 2-dimensional map of pesticide biodegradation kinetics. Objective 1 - Summer 1992.
- For each pedologic horizon and each geologic stratum, a 2-dimensional map of in situ organic C composition. Objective 1 - Spring 1994.
- For each pedologic horizon and each geologic stratum, a 2-dimensional map of pesticide distribution coefficients and organic carbon partition coefficients. Objective 1 - Winter 1995.

Systems Component V

Socioeconomics. Willingness of Land Operators in the Scioto River Basin to Adopt Water Quality Protection Practices.

- Predictive statistical models to assist in determining the willingness of land operators in the Scioto River basin to adopt water quality protection practices. Objective 7 - Fall 1992.
- Identify the factors which will facilitate and/or impede adoption of recommended water quality protection practices at the farm level. Objectives 6 and 7 - Fall 1992 and Summer 1995.

Likelihood of Attaining Objectives

Objectives 3 and 6 may be difficult to attain. Identifying the region where the most promising alternative agricultural systems could be adopted may need additional inputs. The Ohio MSEA team may need to look more into risk assessment models or approaches based on the initial field results.

Transferability, Scale Up, Regionality Potential

The Ohio MSEA project has an excellent opportunity to investigate transferability given the excellent capabilities of the research team members. Plans for collection of a regional database were excellent. However, the Ohio MSEA could serve as a model for extending research results to new areas within the State and to other States.

## Recommendations

The MSEA Study

1. Emphasis needs to continue on the assessment and evaluation of the complex hydrologic processes at the Ohio MSEA project.
2. The Ohio socioeconomic surveys and studies are good. The Ohio MSEA should work with the other MSEA projects to develop a common survey.
3. The Ohio MSEA should identify the region or locations where the most promising alternative agricultural systems could be adopted or transferred from its research.

MSEA Management Team, Research Committee, Agencies

1. The Ohio MSEA could serve as a model for extending research results to new areas within Ohio and to other States.
2. The MSEA Management Team needs to encourage regionalization of results with strong inputs from the Ohio MSEA team.
3. The Research and Development Committee of the USDA Working Group on Water Quality needs to commend the Ohio MSEA team for the assembly of an outstanding team of investigators, appropriateness of the site selected and excellent progress.

## COMMENTS

A need was identified for an appropriate inventory of the resource base with an assessment of the magnitude and extent of the agricultural water quality problem. In addition, determine applicability and the anticipated extent of adaptability of the research findings, and establish costs and benefits of farmers implementing new alternative production systems in the region.

Significant progress was made at the five MSEA locations during the first year of research and development. The recommendations by the review team were acted upon immediately. The program administrators, review team, and MSEA scientists appreciated the exchange of ideas and the opportunity to recommend improvements in current program operations and the research plans.

## MSEA REVIEW TEAMS

| | Review Locations in June,1991 | | | | | |
|---|---|---|---|---|---|---|
| | 3-4 | 4-5 | 6-7 | 11-13 | 17-18 | 19-21 |
| Names/Organization | Overview | Ohio | Missouri | Iowa | Nebraska | Minnesota |
| M. L. Horton, USDA/CSRS | X | X | X | X | X | X |
| D. A. Bucks, USDA/ARS | X | X | X | X | X | X |
| H. Mattraw, USGS | X | X | X | X | X | X |
| Lee Mulkey, EPA | X | X | X | | X | X |
| J. W. Bauder, Montana State Univ | | | | X | | |
| W. L. Hargrove, Georgia Agric Exp Sta | | | | | X | X |
| F. J. Humenik, N. Carolina State Univ | | | | | X | X |
| C. Ullery, USDA/ES | X | X | X | X | | |
| W. Fontenot, USDA/SCS | X | X | | | X | X |
| K. L. Wells, Univ of Kentucky | | | X | X | | |
| S. R. Crutchfield, USDA/ERS | X | | | | | |

# WATER QUALITY RESEARCH--THE PRESIDENT'S INITIATIVE

## ABSTRACTS of RESEARCH PROGRESS

## APPENDIX
## to the
## COMPREHENSIVE REPORT

**1991 Report**
**on**
**1990 Projects**

Agricultural Research Service
Cooperative State Research Service
U.S. Department of Agriculture

in
Cooperation
with

State Agricultural Experiment Stations
and
Collaborators

# APPENDIX

WATER QUALITY RESEARCH: PRESIDENT'S INITIATIVE
ABSTRACTS of 1990 PROGRESS--NATIONAL
June, 1991

## INTRODUCTION

This appendix report contains 101 abstracts of progress in Agricultural research on problems of water quality, resulting from budget increases in FY 1990 to the Agricultural Research Service (ARS) and the Cooperative Research Service (CSRS). The expanded research, addressing the USDA Water Quality Plan and responding to the President's Initiative, involves multi-agency and multi-disciplinary planning and research teams--representing various USDA research agencies and other Federal and State research organizations. Research under the President's Water Quality Initiative is coordinated by the USDA Working Group on Water Quality, and in addition to ARS and CSRS, involves the Economic Research Service (ERS), the State Agricultural Experiment Stations (SAES), and is cooperative with USGS, EPA, ES, SCS, and other Federal and State Agencies as appropriate for the types of research.

There are two types of research programs under the President's Initiative. (1) The Priority Components element expands knowledge of reactions, degradation, persistence, remediation, and many other aspects of an agricultural production system, under a CSRS competitively-awarded national Special Research Grants Program, and a prioritized research program in ARS. (2) The Selected Geographic Systems element, with the first one being the Management Systems Evaluation Areas (MSEA), as part of the Midwest Initiative. It is a long-term, multi-agency, State-Federal Program to evaluate agricultural production management systems that are both economically and environmentally beneficial.

**THE RESULTS REPORTED HERE ARE NOT FINAL AND SHOULD NOT BE CITED WITHOUT PERMISSION OF THE PRINCIPAL INVESTIGATOR**

## COMPONENTS RESEARCH
## National Program

There are 96 projects of Components Research reported by the following abstracts, of which 28 were funded by ARS and 45 by CSRS in 1990. Also included are 23 of the same type projects funded by CSRS in 1989. It should be noted that the ARS projects may include several sub projects, and many of the ARS and CSRS projects involve researchers from other agencies and scientific institutions.

ARIZONA MANAGEMENT PRACTICES AND PREFERENTIAL FLOW TRANSPORT. A. W. Warrick, J. E. Watson, J. P. Chernicky, D. O. Lomen, Univ of Arizona. Report Period: 6/89-4/91.

The field studies and routine soil characterization have been completed as planned. The three tasks which remain are: 1. Conduct soil adsorption batch studies, 2. analyze field and laboratory data to determine the extent of preferential flow (movement) of pesticide, 3. quantify the variability of this preferential flow relative to the variability of preferential flow of tracers. A poster was presented at the Preferential Flow Conference held in Tucson, AZ, April, 1991. Three management practices were studied involving methods of application of the herbicide Prometryn, and its timing relative to irrigation. The methods of application were: 1. Chemigation (simultaneous application of pesticide and water) to initially dry soil, 2. chemigation to initially wet soil, 3. conventional application via spray rig immediately followed by soil incorporation. It appears that in some cases, the application of herbicide via chemigation to initially wet soil enhances the depth of its movement relative to the depth of movement when applied via chemigation to initially dry soil, or when applied conventionally.

ARIZONA DEVELOP A PROTOTYPE DECISION SUPPORT SYSTEM FOR WATER QUALITY MODELING. L. J. Lane, USDA-ARS, Tucson, AZ. Report Period: 4/90-5/91.

Multiobjective decision theory was modified to a) utilize the scoring functions to rank decision variable output from simulation models (CREAMS Hydrology and Erosion) and b) the scoring functions were linearized by segments from the minimum to the average and from the average to the maximum value of each decision variable. Validation data sets for multiobjective procedures--existing data from the US Forest Service, Beaver Creek Experimental Watersheds--are being compiled and processed to test the validity of the multiobjective decision making methodology in selecting best management systems for forest ecosystems. Data will be assembled for a cropland situation at Treynor, Iowa and for rangeland situations at Badger Wash, Colorado and/or Reynolds Creek, Idaho.

ARIZONA MOLECULAR METHODS FOR EVALUATION OF MICROBIAL QUALITY OF GROUNDWATER. I. L. Pepper, C. P. Gerba, S. D. Pillai, Univ of Arizona. Report Period: 6/90-4/91.

Primers have been designed from genes lamB, phoP and the polioviral genome allowing for polymerase chain reaction(PCR) amplification of fecal coliforms, *Salmonella* and *Shigella* sp. and poliovirus, respectively. Amplified product was detected via ethidium bromide staining or end labelled gene probes. These primers are currently being used to detect indicator organisms and specific pathogens in groundwater. Filtering large volumes of water and using PCR allows for increased sensitivity over traditional methods of analysis and also allows detection of viable but nonculturable organisms.

ARKANSAS OPTIMIZING ON-FARM DISPOSAL OF PESTICIDE RINSATES. T. L. Lavy, J. H. Massey, J. D. Mattice, R. E. Talbert, D. C. Wolf, Univ. of Arkansas. Report Period: 9/89-5/91.

Improper handling and/or disposal of leftover pesticide concentrates, spray mixtures, and rinsates from cleaning application equipment have been cited as significant contributors to groundwater contamination. An affordable on-farm system has been developed for quickly and efficiently disposing of these pesticides which serve as potential point source contaminates. For a cost of less than $1200, using readily available components, a functional recycling charcoal filter system can be fabricated. This system effectively removes the pesticides atrazine, benomyl, carbaryl, fluometuron, metolachlor and trifluralin from waste water. Typical concentrations ranging from 300 to 1000 ppm were reduced to less than 10 ppm in less than 2 hours. Current studies involving microbial deactivation of degraded charcoal filters have resulted in a 50% degradation of alachlor on the filters in a 50-day period. A combination of organic dyes is being used to develop a prediction scheme for assessing the capacity remaining on partially spent charcoal filters. These studies will allow the farmer to make more environmentally and legally sound judgments as he disposes of leftover pesticides.

ARKANSAS DEVELOPMENT OF A GEOGRAPHIC INFORMATION SYSTEM TO ANALYZE NITRATE CONTAMINATION FROM THE LAND APPLICATION OF POULTRY LITTER. H. D. Scott, W. F. Limp, M. J. Cochran, Univ of Arkansas. Report Period: 6/89-4/91.

Digitization of soils information, near surface geology, transportation, hydrography, and elevation of the Muddy Fork sub-basin of the Illinois River Basin has been completed. The 1985 land use at a scale of 1:24,000 has been digitized from photo interpretation of aerial color infrared film positives flown in late summer of 1985. The land use quads were plotted onto overlays to be updated with cultural information such as orchard and poultry operations found on the US Geological Survey 7.5 minute quadrangles and from ground truth surveys conducted by Soil Conservation Service and Cooperative Extension Service. The nitrate transport model has been adapted to run on a SPARC station. Additional modules have been developed to describe the volatilization of ammonia and plant uptake of nitrogen. Two ongoing field studies have been used to

validate the nitrogen transport model. A prototype economic model has been developed which will enable the examination between nitrate loadings and farm income. The model is constructed with chance-constraints to allow a probabilistic representation of nitrate loadings.

ARKANSAS & TEXAS MODELING WATER QUALITY IMPACTS OF SURFACE-APPLIED BROILER LITTER TO IDENTIFY BMPs. T. C. Daniel, D. R. Edwards, Univ of Arkansas, and W. L. Bland, R. H. Griggs, Texas A&M Univ. Report Period: 6/90-4/91.

All field plots have been established with uniform slopes and fescue border areas, and instrumented to collect runoff during rainfall simulation. Unsaturated flow measurement devices are being installed including tensiometers, pan lysimeters, and suction cup lysimeters. Methods of analysis for specialty compounds such as Cyromazine have been developed and are being tested under field conditions. The EPIC model is being revised to better reflect nutrient transformation after land application. Three rainfall simulated runs are scheduled for this summer with presentations of preliminary results scheduled at a summer meeting in Norway, and two papers to be presented at the annual meeting of the American Society of Agricultural Engineers.

CALIFORNIA DISSOLVED ORGANIC MATTER IN WATER AND ITS ROLE IN TRACING GROUNDWATER POLLUTION. A. C. Chang, A. L. Page, Univ of California-Riverside. Report Period: 6/90-4/91.

NMR experimental techniques were used to characterize dissolved organic matter (DOM) in soils and in natural water and to determine the interactions of pollutant and DOM. The dissolved organic matter was characterized using $^1H$ NMR and a 1331 solvent suppression pulse sequence for the assay in a natural water sample. The signal of water (the solvent in this case) can be suppressed but the spectrum revealed only one weak signal. We are working with a well characterized humic acid to calibrate other solvent suppression pulse sequences, to determine the degree of concentration and pretreatment needed to obtain a full NMR spectrum of DOM. Interactions of hydrophobic organic pollutants and DOM were measured by their diffusion in aqueous systems. 19F Pulsed Field Gradient Spin Echo NMR was used to determine the diffusion coefficient of fluorobenzene in the presence and absence of dissolved organic matter. Fluorobenzene exhibited two significantly different diffusion coefficients suggesting that part of the chemical dissolved in water is present in free form and the remainder is complexed with the DOM.

CALIFORNIA A WATER DESELENIFICATION PROCESS USING ACCELERATED MICROBIAL VOLATILIZATON. W. T. Frankenberger, Jr., E. T. Thompson-Eagle, Univ of Calif-Riverside. Report Period: 6/90-4/91.

Biomethylation of Se (selenium) in evaporation pond water was studied and optimized in laboratory-incubated mesocosms. Methylating microorganisms were present in all pond waters collected from the San Joaquin Valley, California and were inhibited by bactericides, but not by fungicides. Addition of casein increased bacterial numbers 1000-fold and stimulated Se biomethylation 25-fold. Growth matrices (sand, glass beads or nylon polymers) stimulated Se biomethylation in unamended water, but not in peptone-amended water. Biomethylation was optimal in a well-mixed, aerobic system amended with a protein source. The species of inorganic Se present, $SeO_3^{2-}$ and $SeO_4^{2-}$ had little effect on the methylation efficiency. Increasing the Se concentration in peptone-amended water decreased the percentage of Se removed; however, Selenium removal ranged between 8% and 100% for peptone-amended pond waters containing between 2.2 and 0.02 microgram Se $1^{-1}$, respectively. Biomethylation was inhibited by 0.1 molar nitrate and nitrite but additional $SO_4^{2-}$ had no effect on DMSe release. It may be possible to apply these findings in the design of a bioreactor to deselenify agricultural drainage water.

CALIFORNIA WATER QUALITY MANAGEMENT ON THE WESTSIDE OF THE SAN JOAQUIN VALLEY. H. I. Nightingale, J. E. Ayars, C. J. Phene, R. B. Hutmacher, USDA-ARS, Fresno, CA, Britz Farms, Mendota, CA, and USDA-SCS, Fresno and Davis, CA: Report Period, 4/90-4/91

The objectives are to determine and demonstrate the effectiveness of irrigation management systems, having the potential to significantly reduce the volume of deep percolation or tile drainage water, on chemical quality of the percolating water, including salts and pesticides, and the volume and quality of runoff from furrow irrigation systems. The subsurface drip irrigation systems have been installed on two 30-acre blocks. The system is being prepared for operation in the tomato field. The first tomato irrigations were completed using furrow irrigation. Layflat pipe has been installed and tested during one irrigation in the tomato field. Initial results indicate that the furrow advance time can be reduced using a surge mode with the layflat pipe. Use of shortened run lengths, eighth mile instead of quarter mile, has also resulted in improved irrigation uniformity and reduced surface runoff. The techniques being used will result in reduced deep percolation and runoff and improved fertilizer usage.

CALIFORNIA FIELD TEST OF A STOCHASTIC, ORGANIC SOLUTE TRANSPORT MODEL. D. E. Rolston, M. L. Kavvas, J. W. Biggar, K. M. Scow, B. Hammock, Univ of California-Davis. Report Period: 6/90-4/91.

A major goal of this research is to investigate the many uncertainties that exist in the physical, chemical, and biological processes that alter the fate and transport of contaminants in soil. An intensively-instrumented field site to measure temporally-, and spatially-variable hydraulic and solute transport parameters has been established. Soil hydraulic parameters have been estimated from multistep-outflow experiments on undisturbed soil samples collected from 24 locations within the field. At the same field locations, two in situ water flow experiments allowed for independent estimation of hydraulic parameters. The results indicated considerable discrepancy among the various methods. For the theoretical part of the project, the ensemble mean partial differential equation has been derived for the time-space nonstationary evolution of contaminate transport by unsaturated flow in soils. Theoretical probability distributions for stochastic contaminant transport in time and space are being developed from the solutions of stochastic partial differential equations. These theoretical probability distributions will be compared with measurements of solute transport uncertainties currently being made in the field experiment.

CALIFORNIA WATER QUALITY MODELS FOR IRRIGATED SALT-AFFECTED SOIL. M. T. van Genuchten, S. R. Yates, W. F. Spencer, J. D. Rhoades, D. L. Corwin, USDA-ARS, U.S. Salinity Laboratory, Riverside, CA. Report Period: 5/90-5/91.

The purpose of this project is to develop numerical models and associated decision aids for predicting the movement of water and dissolved chemicals in irrigated salt-affected soil profiles, and to use these models to develop scenarios for achieving agricultural sustainability and salt balance for affected areas. Main emphasis will be on the formulation of computationally efficient numerical schemes which also more accurately calculate one- and multi-dimensional water infiltration in relatively dry soils. Subroutines will be included to account for soil heat flow, multi-component salt transport, evapotranspiration, and crop yield as a function of water and salinity stress in the soil root zone. Results of the study are expected to improve the management of water and salinity in (drip) irrigated agricultural systems, notably for areas with high water tables.

CALIFORNIA ECONOMIC INCENTIVES TO REDUCE AGRICULTURAL POLLUTION OF WATER RESOURCES. James E. Wilen, Catherine L. Kling, Univ of California-Davis. Report Period: 6/90-4/91.

Incentives were studied that motivate water quality improvements when damage functions vary among farms and when much of the pollution is generated by non-point sources. A conceptual model describing the economic and hydrologic linkages among irrigated farms in a drainage problem area has been developed. Drainage policies including higher water prices, drain water

fees, and water marketing opportunities have been examined. Preliminary results describe the usefulness of water markets when non-point sources of pollution limit the efficiency of taxes and standards.

Farm-level crop production, irrigation, and drainage data for 1986 through 1990 have been collected from farms in the drainage problem area. These are being used to estimate crop yield and drain water equations for inclusion in the regional policy model. Preliminary estimates suggest that the role of applied water in determining crop yields may be structurally different than its role in generating drain water. The implications of these results will be examined for alternative policies using the regional model.

COLORADO INTERACTIVE GUI FOR TWO-DIMENSIONAL LEACHING SIMULATIONS. C. V. Alonso, USDA-ARS, and P. C. Lai, Colorado State Univ, Fort Collins, CO. Report Period: 4/90-5/91.

The objective is to develop a Graphical User Interface (GUI) for two-dimensional leaching models. An immediate application of this GUI will be as a driver for a new finite-element solver designed to evaluate row crop situations showing highly prounced spatial variations and temporal changes in soil properties, surface conditions, and contaminant pathways. Major goals are to facilitate multi-dimensional data input and to leverage modeling techniques by adding scientific insight through visualization methods. A fully documented beta-version of the GUI's pre-processor was released in Februrary 1991, and the complete GUI is expected to be ready for beta testing in December 1991.

COLORADO & UTAH PREDICTING PESTICIDE LEACHING FROM SPATIAL VARIABILITY OF TRANSPORT PROPERTIES. I. Broner for J. C. Loftis, P. N. Soltenpour, Colorado State Univ, and R. C. Peralta, R. J. Hanks, Utah State Univ. Report Period: 6/90-4/91.

In the first phase of the project, work was begun on a corn management expert system for reducing ground water contamination by developing a questionnaire and a detailed literature review. The questionnaire was distributed to several corn management experts, with more to be added. The knowledge acquisition will be concluded by the end of the summer of 1991 and cognitive modeling will begin. Phase I of the field-oriented research included samples from designated depths for each soil core, which were analyzed for bromide (tracer) concentration. Statistical analysis of the data is now in progress, with completion of the standard geostatistical procedures and progress on the fractal analysis. Work on the project is proceeding as proposed in the research timetable.

COLORADO PREDICTING PESTICIDE LEACHING FROM SPATIAL VARIABILITY OF TRANSPORT PROPERTIES. D. Durnford for J. C. Loftis, D. B. McWhorter, G. Butters, CO State Univ, and R. E. Smith, H. R. Drake, USDA-ARS, Fort Collins, CO. Report Period: 6/90-5/91.

The first year of research consisted of a field study of spatial variability of pore water velocities using a bromide tracer and a nested sampling design. Statistical analysis of the data is now in progress to determine the correlation structure of pore water velocities at different spatial scales. Standard geostatistical procedures have suggested that the usual models for spatial structure, such as spherical models for semivariograms, may not be appropriate. Fractal models are also being studied.

COLORADO NITROGEN MANAGEMENT TO PROTECT GROUND WATER QUALITY. R. F. Follett, L. K. Porter,M. J. Shaffer, USDA-ARS, Fort Collins, CO. Report Period: 4/90-5/91.

Progress includes: I. Data have been collected on leaching of isotopically labelled-N from field studies under corn fertilized at 4 N-rates and 3 irrigation-rates, based upon potential evapotranspiration, and from a dryland wheat-sorghum-fallow study fertilized at 3 N-rates. Preliminary results indicate that overfertilization caused excessive residual nitrate buildup and that excess water application caused increased leaching hazards, especially where excess residual nitrate was present. II. A book entitled "Nitrogen Management and Ground Water Protection" has been published through Elsevier Science Publications and a second book entitled "Nitrogen Management for Ground Water Quality and Farm Profitability" is currently in the galley-proof

phase for publication by the Soil Science Society of America. III. The NLEAP (Nitrate Leaching and Economic Analysis Package) computer model is undergoing final testing. With this model the user supplies or selects basic information concerning onfarm management practices, crops, soil climate, and economics. It then translates this information into projected water and N budgets, potential hazards of N leaching below the crop root zone, economic impacts, and potential aquifer effects.

CONNECTICUT DEGRADATION OF PESTICIDE WASTES AND CONTAMINATED MEDIA. J. J. Pignatello, Yunfu Sun, Connecticut Agr Exp Sta. Report Period: 6/90-4/91.

Initial studies explored the use of $Fe/H_2O_2$ reagents, which generate highly reactive hydroxyl (HO·) and hydroperoxyl (HOO·) radicals, for degradation of pesticides. At 20 $^oC$, 2,4-D acid was transformed in minutes by dilute aqueous solutions of $H_2O_2$ and Fe(II) or Fe(III) salts. The Fe(III)-catalyzed reaction was found to be most important to degradation. The maximum rate occurred at pH 2.7-2.8. Chloride was liberated quantitatively and nearly simultaneous with loss of 2,4-D. 2,4-Dichlorophenol was a minor transient intermediate. Both ring-, and carboxy-$^{14}C$-2,4-D were greater than 95% mineralized to $^{14}CO_2$ after 6 d. Some iron chelates permitted mineralization at neutral pH. 2,4,5-T acid gave similar results: 2,4,5-trichlorophenol was a transient intermediate; $Cl^-$ was evolved quantitatively; and $^{14}CO_2$ was produced in greater than 95% yield. Preliminary experiments indicated metolachlor and atrazine also were transformed by the reagent.

DELAWARE NITRATE FROM SOYBEANS AND SUBSEQUENT CONTAMINATION OF GROUNDWATER. J. J. Fuhrmann, B. L. Vasilas, Univ of Delaware, and J. S. Angle, Univ of Maryland. Report Period: 7/90-4/91.

In the first year of studying nitrate, soybean and fescue control plots have been established on a Coastal Plain soil in Delaware and a Piedmont soil in Maryland, and sampled as described in the proposal. Based on analysis of samples from the Delaware site (analyses for the Maryland site were in progress at time of this report), there was no evidence of elevated nitrate levels in groundwater under soybeans as compared to the fescue controls. Rather, nitrate concentrations in groundwater under soybeans were significantly lower than those under fescue beginning soon after soybean establishment. However, soil samples collected after soybean harvest had significantly higher nitrate concentrations in the upper soil profile under soybeans than under fescue. This nitrate may be subsequently leached deeper in the soil, or to groundwater, depending on precipitation and soil and crop management after soybeans.

DELAWARE LEACHING, SORPTION AND BIODEGRADATION OF HERBICIDES IN SUBSOILS OF A COASTAL PLAIN WATERSHED. J. T. Sims, J. J. Fuhrmann, D. L. Sparks, Univ of Delaware. Report Period: 9/89-12/90.

The sorption and mobility of atrazine and metolachlor were studied on different horizons of four Delaware Coastal Plain soils. Sorption and mobility data were obtained by a modified batch procedure and soil thin-layer chromatography (TLC). Distribution coefficients (Kd) were calculated from both procedures indicating that atrazine and metolachlor possessed similar leaching potentials. This potential would be lower in soil horizons containing high amounts of organic matter or clay and higher in sandy, low organic matter horizons. Multiple regression analysis identified organic matter and exchangeable acidity as important variables in predicting both sorption and mobility in surface and subsoils.

FLORIDA DEGRADATION OF TELONE II AND FENAMIPHOS IN SUBSOILS AND GROUNDWATER, AND BY MICROORGANISMS. Li-Tse Ou, Univ. of Florida. Report Period: 7/90-4/91.

This study is to determine degradation and metabolism of the two nematicides, Telone II and fenamiphos, in subsoils and groundwater. Degradation rates of Telone II in subsoil samples

collected from a Telone experimental site in Florida progressively declined as soil depth increased, while the rates in groundwater samples were much lower. Several bacteria isolated from the soil samples were found to have the capacity to degrade Telone II. Mineralization rates of fenamiphos in surface and subsurface soil samples, collected from a turfgrass field with over 15 years of annual fenamiphos application, were much higher than that in control. No mineralization was observed in water samples collected from the site. Several mixed bacterial cultures capable of degrading fenamiphos were isolated from the soil samples.

GEORGIA ROLE OF WINTER COVER CROPS IN REDUCTION OF $NO_3$ LEACHING. J. W. Johnson, W. L. Hargrove, J. E. Box, P. L. Raymer, Univ of Georgia. Report Period: 7/90-4/91.

The overall objectives of this research are to evaluate several winter annuals for rooting depth and residual nitrogen recovery and to measure the influence of a winter cover crop on the amount of nitrate leaching during fall, winter, and spring months. In a preliminary screening of sixteen winter annual plant selections--9 species, the most promising plant materials were winter rye, wheat, triticale, and canola. Three plant materials, rye, canola, and crimson clover were selected for detailed study of rooting depth and N uptake. Results from 1991 show that rye is superior in terms of rooting depth, biomass production, and N uptake. Rye removed a total of 120 kg N/ha, reducing the soil nitrate-N concentration to about 5 ppm to a depth of 1 m. In Phase III, to begin in 1992, the amount of water and nitrate moving through the soil profile under different crops will be measured using tile drains installed in field plots.

GEORGIA Develop Decision Aids and Other Model-Based Systems for Enhancing Water Quality and Farm Profitability. R. A. Leonard, D. D. Bosch, USDA-ARS, and W. G. Kneisel, D. D. Beasley, Univ of Georgia, Tifton, GA. Report Period:

Plant nutrient-animal waste components for inclusion in the GLEAMS model have been formulated. New algorithms are also being developed to partition phosphorus between soil/sediment and water that are functions of soil properties and past phosphorus loadings. A third year of field data from an ARS, USGS, EPA, UGA study near Plains, Geogia on atrazine, alachlor, carbofuran, and bromide fate and transport are being completed and compiled for preliminary model testing and evaluation by the respective agencies.

HAWAII LIQUID CHROMATOGRAPHIC METHODS FOR PESTICIDES IN WATER. C. J. Miles, Univ of Hawaii. Report Period: 6/90-4/91.

Multiresidue methods for pesticides in water were developed using liquid chromatography (LC) with postcolumn reaction detection. Over 100 analytes from the U.S. Environmental Protection Agency's National Survey of Pesticides in Drinking Water Wells were screened for response using postcolumn photolysis followed by fluorescence (PFD), electrochemical (PED) or conductivity (PCD) detection. LC-PED and LC-PFD are suitable for multiresidue pesticide determinations in groundwater. These two detectors are complimentary since the PED responds to several sulfur-containing pesticides while the PFD responds to many nitrogenous pesticides. Approximately half of these analytes could be determined in low nanograms amounts using these two detection systems, and multiresidue separations with gradient reversed-phase LC have been demonstrated. The LC-PCD system tested was not suitable for sensitive, multiresidue determinations and further examination of this technique is recommended using the commercial PCD.

HAWAII & ALABAMA APPLICATION OF FRACTAL GEOMETRY FOR ESTIMATING SOIL HYDRAULIC PROPERTIES. Goro Uehara, G. Y. Tsuji, Univ of Hawaii, and A. Singh, Intl Fert Dev Center, Alabama. Report Period: 6/90-4/91.

Particle size distribution and water retention curves of soil materials can be treated as fractal distributions. The log-log plot of particle size versus percent cumulative mass or water content versus soil water pressure results in a straight line between an upper and lower particle size or water pressure limit. The slopes of the lines between the lower and upper limits for particle size

and water retention are highly correlated. This correlation allows the water retention characteristic of a soil sample to be estimated from particle size distribution data. Since the water retention characteristic corresponds to pore size distribution, the diffusivity-water content relationship can be estimated from the water retention data. The ease with which soil hydraulic parameters can be obtained by these estimation procedures should enable users to apply soil water models in data-sparse regions and other situations.

IDAHO MICROBIAL DETOXIFICATION OF PESTICIDE CONTAINERS AND RINSATES. R. L. Crawford, D. C. Thill, H. W. Horman, Univ of Idaho. Report Period: 6/90-4/91.

Objectives are to develop immobilized microbial preparations that can be used to degrade residues of herbicides and other toxic components, remaining in used chemical containers or dissolved in agricultural industry rinse waters. We have optimized preparations of bacteria of the genus Pseudomonas that degrade 2, 4-dichlorophenoxyacetic acid, dicamba, and parthion. These target chemicals can be degraded in a few hours to very low or non-detectable levels by the microbial preparations, using conditions readily attainable by agricultural chemical applicators under farm or field conditions. Freeze-dried, immobilized preparations of the microorganisms will be examined this summer for their shelf-life and effectiveness.

ILLINOIS HERBICIDE DISSIPATION AND WEED CONTROL MODELS FOR REDUCING HERBICIDE CONTAMINATION OF GROUNDWATER. M. G. Huck, L. M. Wax, USDA-ARS, Urbana, IL. Report Period: 4/90-4/91.

Field studies showed marked differences in maize root growth response to nitrogen (N) fertilization. Vegetative proliferation of roots was correlated with N fertilization, which permitted more efficient extraction of water held in the subsoil under drought conditions. A general 2-dimensional computer model for water flow through porous media--licensed by ARS from HydroGeologic, Inc. for use throughout the agency--was adapted to the GLYCIM model for soybean growth and tested against experimental measurement data collected in the Auburn rhizotron between 1981 and 1983. Predictions of root growth and water movement were quite accurate on dry-down, but infiltration through macropores was not considered by the model, which assumes a homogeneous porous medium, resulting in sizeable predictive errors following heavy rainfall or irrigations. Perfecting water flow prediction is essential for acceptable estimates of solute movement to groundwater.

ILLINOIS WEED MANAGEMENT AND APPLICATION TECHNIQUES FOR GROUNDWATER QUALITY PROTECTION. L. M. Wax, J. W. Hummel, E. W. Stoller, D. M. Alm, USDA-ARS, Urbana, IL. Report Period: 4/90-4/91.

The overall objective is to provide the knowledge for efficacious use of herbicides while protecting water resources in corn and soybean production systems. We are investigating and modeling the effects of spray transport, impact, and deposition mechanisms through analysis of data from wind tunnel droplet size and velocity studies. Research is underway to provide biological data for the development, verification, and augmentation of bio-economic weed models in cooperation with MN. Weed management and herbicide application systems utilizing reduced chemical inputs for corn and soybeans are being developed, along with image processing protocols for pesticide applicator guidance systems that can be easily adapted to current custom applicator equipment.

ILLINOIS & NORTH DAKOTA EVALUATION OF NATURAL ABUNDANCE $^{15}N$ TECHNIQUES FOR GROUNDWATER NITRATE STUDIES. R. M. Vanden Heuvel, R. L. Mulvaney, Univ of Illinois, L. Prunty, B. R. Montgomery, North Dakota State Univ. Report Period: 5/89-4/91.

Nitrate ($NO^{3-}$) contamination of groundwater has become an important issue, but before remedial action can be taken to correct the source, the origin of the nitrate needs to be known. A method to identify sources of nitrate in groundwater involves the use of natural abundance $^{15}N$ values. The hypothesis is that there exists a consistent and measurable difference in the natural abundance

$^{15}N$ concentration of $NO^{3-}$ derived from commercial fertilizers, manure, and soil organic matter. These differences can then be used to identify and quantify sources of nitrate.

A nitrate leaching experiment was conducted in a field lysimeter comparing natural abundance $^{15}N$ techniques to more sensitive conventional $^{15}N$-enriched techniques. Natural abundance background $^{15}N$ is quite variable, being about 40% of the possible range, which limits use of natural abundance $^{15}N$ methodology. Although the study was conducted on a sandy soil, having good potential for success, natural abundance techniques failed to detect residual nitrate from fertilizer as compared to the conventional $^{15}N$-labeled method.

ILLINOIS & OHIO WATER FLOW AND HERBICIDE TRANSPORT THROUGH SOIL MACROPORES. F. W. Simmons, C. W. Boast, Univ of Illinois, and E. L. McCoy, The Ohio State University. Report Period: 8/90-5/91.

Herbicide movement through earthworm channels is a suggested mechanism for transport of soil applied herbicides through the root zone. Precipitation history shortly after herbicide application may be important in determining delivery of herbicides in macropore or soil matrix flow. We tested the hypothesis that a light rain may move herbicides into the soil matrix thereby allowing cleaner bypass flow in subsequent rainfall events. Undisturbed 7.5-cm diameter soil cores containing a single continuous macropore were sampled from a Drummer silty clay loam. Four saturation level groups between 0.30 and 0.80 were surface sprayed with alachlor, metolachlor, and atrazine. Half of the samples were then "pretreated" with a 0.25-cm rainfall then subjected to either 1.25 or 2.50-cm of rain. Herbicide and bromide movement was reduced an average of 37-76% when a 0.25-cm rainfall preceded greater rainfall events. Doubling the rainfall rate resulted in increases of 168 to 225% in herbicide delivery through the macropores. Of the herbicide entrained in the macropore, 6-17% was sorbed to the 7.5-cm long macropore wall. Rainfall amount and rainfall history following herbicide application will have a strong effect on herbicide entry into macropores. The sorption and hydraulic environment of the macropore system will determine ultimate delivery through the solum.

INDIANA & GEORGIA DECISION SUPPORT SYSTEMS FOR EVALUATING GROUNDWATER QUALITY PROBLEMS. B. A. Engel, K. M. Embleton, J. P. Gurganus, X. Zhuang, D. D. Jones, J. D. Eigel, Purdue Univ, D. B. Beasley, M. C. Smith, Univ of Georgia, and R. L. Leonard, W. G. Knisel, USDA-ARS, Tifton GA. Report Period: 6/90-4/91.

A structure has been developed for constructing the decision support system to evaluate groundwater quality problems. Most of the required printed information, data bases, and models have been accumulated. Development of modules that will become part of the system has started with plans to begin coding of modules in the early summer of 1991. Some modules have been completed and are being used at many locations. Purdue-Georgia project personnel continue to exchange information that will be used to build the modules. Laboratory and field data for module development and testing are being collected at Tifton, Georgia.

The GLEAMS model has undergone additional testing and development, including midwestern U.S. conditions using 5 years of data for a field study in southeast Indiana. GLEAMS did reasonably well in estimating masses of pesticides that moved through the root zone and the timing of their appearance in tile flows.

INDIANA, ILLINOIS, NEBRASKA & IOWA CONTROLLED RELEASE HERBICIDE FORMULATIONS--THEIR EFFICACY AND ROLE REDUCING GROUNDWATER CONTAMINATION. M. M. Schreiber, M. Hickman, W. Lafayette, IN, L. M. Wax, Urbana, IL, D. Buhler, W. M. Doane, Peoria, IL, all USDA-ARS; R. Harrison, Univ of Nebraska, M. Owens, Iowa State Univ, T. T. Bauman, Purdue Univ. Report Period: 1/90-12/90.

Repeated laboratory studies on leaching of atrazine, alachlor and metolachlor indicate that starch encapsulated (SE) formulations significantly reduce the leaching of these herbicides compared to

commercially available formulations (CAF). Three inch rainfalls moved emulsifiable concentrate formulations of atrazine over 20 cm into silt loam or sandy soils. SE formulations were leached only 5-7 cm under similar conditions. Results with alachlor and metolachlor were similar. Field data from 10 locations in 6 states during the 1990 growing season indicated good to excellent control of most weed species and equal or better corn yields. Control of some large weed seed species such as velvetleaf and cocklebur was variable from one location to another. Considering treatments were surface applied, the formulations were all 14-20 mesh size, and no cultivars were grown under conventional tillage, the results indicate great potential for SE formulations. Analysis of soils for residues, with sampling at 3 locations, are not completed.

IOWA AVAILABILITY OF ORGANIC CARBON FOR DENITRIFICATION OF NITRATE IN SUBSOILS AND GROUNDWATERS. J. M. Bremner, G. W. McCarty, Iowa State Univ. Report period: 9/89-4/918-.

The slow rate of denitrification in Iowa subsoils was not due to a lack of denitrifying microorganisms but to a lack of organic carbon that could be utilized by these microorganisms for denitrification of nitrate. Studies concerning movement of organic carbon from surface soils to subsoils showed that drainage water from tile drains under agricultural research plots contained only trace amounts of organic carbon and had very little, if any, effect on denitrification of nitrate in subsoils. Other studies showed that aqueous extracts of surface soils promoted denitrification in subsoils and that their ability to do so increased with increase in their organic carbon content. The effects of incubating surface soils with corn and soybean residues for various times showed that although amendment of surface soils with these residues led to a marked increase in the amounts of organic C in aqueous extracts of the soils and in the ability of the extracts to stimulate denitrification in subsoils, these effects were short-lived and could not be detected after incubation of residue-treated soils for 1 or 2 days.

IOWA GROUNDWATER RECHARGE AND CHEMICAL TRANSPORT IN TWO GLACIAL TILL CONFINING UNITS IN IOWA. R. S. Kanwar, W. W. Simpkins, R. O. Horton, T. E. Fenton, L. C. Jones, J. L. Baker, Iowa State Univ and G. R. Halberg, Iowa Dept Natural Resources, Iowa City, IA. Report Period: 4/90-4/91.

Monitoring wells for detailed groundwater studies have been installed at both locations. Preliminary results indicate that groundwater above 7m is less than 20 years old. For piezometers deeper than 4.5m, the pesticide concentrations were below the detection limit, and nitrate-nitrogen ($NO_3$-N) concentrations were less than 1 mg/l. Data on corn yield and $NO_3$-N concentrations in subsurface drainage water indicate that split N-fertilizer applications at a lower rate of 125 kg/ha could produce as much yield as a single N-fertilizer application at a higher rate of 175 kg/ha. This split application significantly reduced the $NO_3$-N concentrations in tile drainage water to mostly less than 10 mg/l, which is a drinking water standard. A large vertical borehole cavity--3.15m in diameter and 3.0m deep--has been installed at the Ames site to facilitate installation of a complex of lateral suction lysimeters. Data from the lysimeter samples will be used to gain an understanding of chemical transport mechanisms under natural precipitation and unsaturated flow in the soil.

IOWA DEVELOPMENT OF FARMING MANAGEMENT SYSTEMS TO IMPROVE WATER QUALITY. J. L. Hatfield, T. B. Moorman, T. R. Steinheimer, USDA-ARS, Ames, IA. Report Period: 1/90-4/91.

Available technology on different farming systems has been cataloged and is being examined in terms of simulation models for pesticide and nitrate movement in the root zone. There are significant gaps in understanding the complete year-around processes, e.g., effects of tillage practices and processes occurring throughout the winter, which will be addressed as the experimental plans are instituted in 1991. At the Walnut Creek watershed near Ames, studies are being set up on different fields to assess the impact of changing farming systems on surface water, tile flow, and ground water. A study to evaluate the mutagenic potential of water will be instituted this spring at several locations throughout Iowa.

<u>IOWA</u> TRANSPORT AND CHEMICAL TRANSFORMATION OF PESTICIDES IN AGRICULTURAL SYSTEMS. J. L. Hatfield, T. B. Moorman, T. R. Steinheimer, USDA-ARS, Ames, IA. Report Period: 1/90-4/91.

A data base of degradation rates of the pesticides, atrazine, alachlor, metribuzin, metolachlor, carbofuran, and turbofos has been assembled from the current literature. This survey will facilitate defining the kinetics of the degradation process for parent and metabolite products of these compounds and the reported variations in the degradation processes, and are being used to target the studies to be conducted. A survey has identified several fields having a long history of atrazine use of greater than 15 years; several other fields have histories of atrazine use, but none during the past 5 years. Both of these conditions will be sampled to determine the relative distributions of parent chemicals and metabolites within the soil profiles. This will provide a validation of certain rates of degradation given in the literature.

<u>IOWA</u> ANALYTICAL DETECTION OF CHEMICALS IN THE SOIL AND GROUNDWATER. J. L. Hatfield, R. L. Pfeiffer, USDA-ARS, Ames, IA. Report Period: 1/90-4/91.

An array of analytical equipment and methodologies for the detection of alachlor, atrazine, metribuzin, metolachlor, nitrate, and ammonia in water and soil samples has been developed and evaluated. These procedures include the robotized extraction of organics from soil with GC analysis and the solid phase extraction from water with GC/MS analysis. Over 2000 water samples and a 1000 soil samples have been analyzed to date. A Quality Assurance/Quality Control procedure for all aspects of the sample collection and analysis process has been developed and evaluated. To improve the throughput on water samples a robotic procedure for solid phase extraction from water has been developed and is currently being evaluated. The analytical capability of this laboratory serves all five Management Systems Evaluation Areas of the Midwest Initiative on Water Quality. Soil from each area has been evaluated for potential problems in analyte recovery.

<u>IOWA</u> DECISION AID SYSTEMS FOR FARMING MANAGEMENT AND WATER QUALITY. D. B. Jaynes, J. L. Hatfield, S. D. Logsdon, USDA-ARS, Ames, IA. Report Period: 7/90-4/91.

Equipment for measuring hydraulically active macropores was developed for the 1991 field season, to facilitate obtaining data for use in relating differences in preferential flow of water and solutes for different soil and crop management systems used for different soils, topography, and climate. Hydraulic data and samples for chemical analyses are being collected from the Walnut Creek part of the Iowa MSEA project where potholes, other topographic features,and soil and crop management differences exist. Initial characterization of the 80-acre field included surveying with a non-contacting electro-magnetic induction meter, which indicated several potholes by the differences in conductance, caused by variability in water content. The root zone water quality model (RZWQM) will be utilized in these studies. Ultimately, the intent is to develop a decision aid system which will permit a more effective management of the soil water, nitrates, and pesticides in crop management systems through integration of adequate hydraulic components that reflect field conditions.

<u>IOWA</u> IMPACT OF PREFERENTIAL FLOW ON CHEMICAL AND WATER MOVEMENT IN AGRICULTURAL SYSTEMS. D. B. Jaynes, S. D. Logsdon, J. L. Hatfield, Ames, IA. Report Period: 7/90-4/91.

Several experiments have been completed except for chemical analyses of samples. Plans have been made for characterizing soil physical and hydraulic properties on Iowa MSEA sites for use as input in solute transport and preferential flow models. Equipment for the determination of soil texture, bulk density, water retention, and unsaturated conductivity has been prepared and tested for use in the 1991 field season. Cooperative research programs have been established with the USDA-ARS laboratory at Phoenix, AZ and Colorado State University to study transport processes under irrigated conditions. Work at Arizona is in its first year, while the first year of data has been collected at Colorado and is awaiting chemical analysis. A workshop to assure coordination of

techniques was conducted at the National Soil Tilth Laboratory at Ames focusing on methods of measuring preferential flow in the field and current state-of-the-art methods for modeling the flow mechanisms.

**KENTUCKY** EFFECTS OF RIPARIAN VEGETATION ON WATER QUALITY: MODELING AND EXPERIMENTAL STUDIES. B. J. Barfield, R. L. Blevins, V. P. Evangelou, Univ of Kentucky, and D. I. Carey, KY Geological Survey. Report Period: 6/90-4/91.

The research is directed toward evaluating and predicting the impacts of channelization on trapping of sediment and chemicals in natural riparian grass vegetation, that could otherwise contaminate ground or surface water. Preliminary field tests were conducted on a 45 foot natural riparian fescue grass vegetation strip on a 6% slope at the University of Kentucky Agricultural Experiment Station Spindletop Farm. A conventional-tillage bare soil plot with a 9% slope, treated with phosphorous (P) at 100 lb/a $P_2O_5$ and 2 lb/a of atrazine, was the source area for sediment, runoff, and chemicals. Rainfall was applied artifically one day later using the Kentucky Rainfall Simulator at the rate of 2.08 in/48 min. Although 3 t/a of sediment moved from the source area, only 149 lb/a reached the end of the grass filter, a trapping efficiency of 98%. Only 29% of the runoff went beyond the filter, with natural channelization causing less than 50% of the filter strip being effective. A model of the trapping of sediment is being developed utilizing probability distributions for flow in channels.

**LOUISIANA** PERCEPTIONS OF WATER QUALITY PROBLEMS AMONG RURAL RESIDENTS OF SOUTHWEST LOUISIANA. E. Jane Luzar, G. W. Wilkerson, Lousiana State Univ. Report Period: 7/90-4/91.

Progress on the research includes entering Louisiana Department of Environmental Quality and Louisiana Geological Survey well monitoring data into a GIS for Southwest Louisiana. Parishes with monitored wells within the Chicot Aquifer have been digitized into a GIS reference file for development of the economic survey sample selection. A detailed literature review on the role of attitudes and perceptions in evaluation of environmental amenities such as water quality has also been completed.

**LOUISIANA** ATRAZINE AND METABOLITE TRANSPORT IN THE SOIL ROOT ZONE AND QUALITY OF GROUNDWATER OF SHALLOW WATER-TABLE SOILS. H. M. Selim, Louisana State Univ and G. H. Willis, L. M. Southwick USDA-ARS, Baton Rouge, LA. Report Period: 6/90-4/91.

Research plots were initiated on sharkey soil cropped to sugarcane, with tile drains spaced at 6 and 12m. All tile drains are located at 1m below the soil surface. Atrazine was applied in June followed by another application in December, 1990. Results following the June application showed a sharp rise in concentration in the tile effluent of the herbicide atrazine, followed by a slow decrease for a period of two months. Maximum atrazine concentrations were 83 and 220 ppb for the 6 and 12m tile spacings, respectively.

We continue to monitor the amounts of water and concentrations of atrazine in the effluent and the distribution of atrazine in the soil profile. Core samples from the surface soil were collected three times following herbicide application. We also installed solution samplers at various soil depths up to 1.8 meters to follow the fate of atrazine. A new atrazine application will be made in June 1991 and its mobility will be monitored using the solution samplers and samples from the effluent outflow from the drains.

**MARYLAND** PREDICTION OF GROUNDWATER CONTAMINATION FROM GENETICALLY ENGINEERED MICROBES. J. S. Angle, R. L. Hill, Univ of Maryland, Report Period: 7/90-4/92.

This study will investigate the rate of transfer of plasmid DNA from a genetically-engineered microbe (i.e. Pseudomonas aeruginosa) to indigenous soil bacteria which are capable of being leached through the soil profile and potentially contaminate groundwater. A predictive equation

will be formulated to estimate the rate of movement of recipients (transconjugants) through the soil profile. Two laboratory studies will be completed using small and large undisturbed soil columns, respectively. Preliminary studies of Pseudomonas aeruginosa population dynamics have been completed. The bacteria exhibit an initial population growth spurt after introduction to the soil which is followed by exponential decay. Equipment for the small column study is not commercially available and its construction, a research contribution to the literature, is nearing completion. A difficult problem has been devising an economically feasible method to keep the leachate sample cold without the risk of freezing the sample and subsequent cell disruption. A soil with a sandy loam surface phase has been identified, limed, and tilled. Column studies are scheduled during Summer,1991.

<u>MARYLAND</u> DEGRADATION OF PESTICIDE WASTE BY OZONE AND MICROBIAL METABOLISM. C. J. Hapeman-Somich, D. R. Shelton, USDA-ARS, Beltsville, MD. Report Period: 1/90-4/91.

A pesticide waste disposal system under investigation consists of treatment of the waste with ozone followed by mineralization--conversion of material to its elemental forms--using microorganisms. Mineralization of atrazine, a triazine pesticide, was slow relative to other pesticides. A microorganism selected to degrade triazines was completely inhibited in field trials. The overall process was reexamined and it was determined that ozonation should be continued until only 2-chloro-4-amido-6-amino-s-triazine (CDAT) and 2-chloro-4,6-diamino-s-triazine (CAAT) remained. A new microorganism (DRS-I), isolated from sewage sludge, was capable of utilizing CAAT as a nitrogen source. In batch reactor studies, DRS-I degraded CAAT in the presence of external nitrogen sources, an attribute which is necessary since pesticide wastes often contain large amounts of ammonia from fertilizers. Experiments demonstrated that CAAT was transformed to carbon dioxide. Organisms grown in two different bench-scale reactors continued to exhibit the ability to degrade CAAT. A redesigned large scale system incorporating these results is under construction.

<u>MARYLAND</u> THE ARS PESTICIDE PROPERTIES DATABASE. S. R. Heller, B. Acock, A. E. Herner, USDA-ARS, Beltsville, MD. Report Period: 5/90-4/91.

The first version of the ARS Pesticide Properties Database, containing data on 16 properties of 92 pesticides was released in October 1990. All data are referenced to the original source. Many of the data have come from the manufacturers through the help and encouragement of the National Agricultural Chemicals Association, and all manufacturers were asked to review data on their products before release. The database is being used by soil modelers trying to predict the potential of various pesticides to leach into ground water under a range of weather and soil conditions.

The data on pesticide properties given in the agro-chemical handbooks are highly variable, unreferenced and cannot be trusted. The ARS Pesticide Properties Database is much more reliable because the source of all data is known and most of the data were produced recently using the latest methodology.

<u>MARYLAND</u> NUTRIENT MANAGEMENT EXPERT SYSTEM. H. Lemmon, J. Bartulovitch, B. Acock, USDA-ARS, Beltsville, MD. Report Period: 2/91-4/91.

The Nutrient Management Expert System (NUMEX) accumulates data on the residual fertilizer content of a field soil submitted for analysis, the nutrient content of any manure or sewage sludge available, and the history of the field. It then makes recommendations to the farmers about the amounts of manure, sludge and commercial fertilizers to apply in order to feed their crop without contaminating surface water or groundwater. NUMEX takes into account the slope and erodability of the field, and the leaching potential of the soil. It calculates the likely nitrate content of the soil based on field history, and the accumulation of heavy metals from sludge applications. NUMEX was originally developed for the soil testing lab of the University of Maryland which provided the performance specification and the expert knowledge. NUMEX is now being adapted to the Midwest corn-growing states.

MASSACHUSETTS DAIRY MANURE ON ALFALFA TO REDUCE OVERAPPLICATION AND N LOSS FROM CORN FIELDS. S. J. Herbert, P. L. M. Veneman, J. Daliparthy, L. J. Moffitt, Univ of Massachusetts. Report Period: 6/90-4/91.

Field experiments were conducted to study the impact of dairy manure application on alfalfa. This is an alternative to excess manure application to corn, which may result in significant nitrate pollution of ground water. Treatments were an unfertilized zero-nitrogen (N) check, low manure (112 kg N/ha), high manure (336 kg N/ha), low and high fertilizer (112 and 336 kg N/ha) as ammonium nitrate. Manure was applied after the first harvest of alfalfa. Water samples were collected through suction lysimeters placed at 30, 60, 90 and 120 cm depth. Application of manure did not increase the occurrence of weeds in this first year. Significant concentrations of nitrate-N were observed in water samples from N fertilizer plots, whereas concentrations in leachate from low or high manure treatments were low. These preliminary results suggest that farmers could apply manure to alfalfa, at rates of 20 to 30 tons per acre without an adverse effect on ground water quality.

MICHIGAN ASSESSMENT AND MODELING OF NITRATE LEACHING UNDER CONVENTIONAL AND ORGANICALLY MANAGED CORN. E. A. Paul, P. R. Grace, G. H. Harris, O. B. Hesterman, J. T. Richie, K. Paustian, Michigan State Univ, S. E. Peters, R. R. Janke, K. Kroll, Rodale Research Center, J. A. E. Molina, Univ of Minnesota. Report Period: 9/90-4/91.

The primary objective of this experiment is to measure and compare nitrate-nitrogen (N) leaching in two types of crop and soil management systems; namely, sustainable (N-source primarily from legumes) and conventional (N-source largely from fertilizer). Drainage lysimeters have been installed around intact soil columns in these plots of the long-term "Conversion" experiment at the Rodale Research Center near Kutztown, PA. A previous study using $^{15}N$ showed that loss of legume N and fertilizer N in these plots varied with climate/years but was similar over a two-year period. Applying $^{15}N$ to lysimeters in this experiment will document loss of applied N, as well as indigenous soil N, by leaching. The $^{15}N$ data will also aid in the development and validation of a computer simulation model that accurately predicts nitrate leaching in cropping systems generating legume N and those utilizing fertilizer N.

MICHIGAN & KANSAS STRATIFICATION AND FATE OF N WITHIN SOIL PROFILES: MANAGEMENT INDUCED CHANGES. F. J. Pierce, J. R. Crum, B. D. Knezek, Michigan State Univ, and C. W. Rice, M. D. Ransom, R. E. Lamond, Kansas State Univ. Report Period: 5/90-4/91.

To determine the stratification and movement of nitrate nitrogen (N) in different soil and climate conditions, comparisons were made between Michigan and Kansas. Corn and soybeans were grown on a Kalamazoo loam soil in Michigan under conventional tillage (CT), no-tillage (NT), and ridge tillage (RT) treatments. Within each tillage system, two levels of N and a zero-N check were imposed on plots having a history of manure application and none. In Kansas corn was grown on a Kennebec silt loam under NT and chisel-disk (CD), with no added N or two N-rates of 84 and 168 kg/ha, applied as either N fertilizer or manure. Corn grain yields in 1990 at the MI site were relatively low, but significantly higher for NT than for either CT or RT. Soybean yields were highest under NT with broadcast herbicide applications. In KS, with better climate conditions in 1990, corn yields averaged 11.0 Mg/ha and were not significantly affected by tillage differences or N application. N uptake by the crops was significantly greater for all N applications as compared with no N. Soil samples are being analyzed for nitrate-N to determine management influence on N movement.

**<u>MINNESOTA & NEBRASKA</u>** INTEGRATION OF N MANAGEMENT ALTERNATIVES TO MINIMIZE GROUNDWATER CONTAMINATION. G. Malzer, P. Robert, D. Baker, J. Moncrief, R. Levins, Univ. of Minnesota, G. Hergert, D. Martin, D. Watts, Univ of Nebraska, J. Schepers, USDA-ARS, Lincoln, NE, and R. Beck, CENEX/Land O'Lakes, St. Paul, MN. Report Period: 8/89-4/91.

The purpose of this project is to develop a computer-based expert system that allows site specific nitrogen (N) fertilizer recommendations that are economically and environmentally sound. Teams from Minnesota and Nebraska have met quarterly to define conditions for site specificity, economic and environmental concern, and economic and logistical feasibility. Prototype systems have been developed and are currently being evaluated. These expert systems permit site specificity by accessing local soil survey information which, along with user management information, will determine the minimum rate of fertilizer N needed for each soil to obtain acceptable crop production. The components are integrated together to provide management recommendations that will minimize N loss during the growing season.

**<u>MINNESOTA</u>** ISOPOTENTIAL ION EXTRACTION OF PESTICIDES. N. T. Basta, A, Olness, USDA-ARS, Morris, MN. Report Period: 6/90-4/91.

A new method for the extraction of pesticides from soils has been developed. In this method, soil-methanol suspensions are equilibrated for 5 days with a device containing XAD resin extractor (RE). Subsequently, the extracted pesticides are recovered from the RE by using methanol and are determined by standard gas chromatographic methods. Results obtained by the RE method were compared with those obtained by standard soil extraction methods. The amounts of pesticide extracted from the soil followed the sequence: the standard method (80% MeOH soil extraction) was equal to or greater than the RE method, which was equal to or greater than a 20% MeOH soil extraction, which was equal to water extraction.

**<u>MINNESOTA</u>** EFFECTS OF SOIL FREEZING ON THE FATE OF SOIL APPLIED NITROGEN AND PESTICIDES. G. R. Benoit, J. A. Daniel, J. A. Staricka, USDA-ARS, Morris, MN. Report Period: 1/90-4/91.

Field studies are underway to evaluate frost-landscape effects on winter movement of nitrate-N and atrazine to surface and ground water. A field with 2 depressions has been selected and surveyed. Background yield and soil samples have been collected on a 30-meter grid. A transect across one depression is instrumented to measure total and unfrozen water content, snow and frost depth, and soil temperature. Frozen and unfrozen soil and water samples were taken over winter. Water flow data from piezometer, groundwater well and soil water data show ponding followed by focused recharge in the depression during melt periods. The second depression has 4 replications of 4 tillage residue systems, each split with two levels of nitrogen and atrazine and instrumented to show water, nitrate, and atrazine movement. Preliminary results show frost-induced movement of soil water. Soil and water samples collected over winter are scheduled for analysis during the summer of 1991.

**<u>MINNESOTA</u>** SORPTION-DESORPTION PROCESSES AFFECTING PESTICIDE MOBILITY IN TILLED SOILS. C. E. Clapp, W. C. Koskinen, S. A. Clay*, D. A. Laird, R. R. Allmaras, D. R. Linden, J. M. Baker, R. H. Dowdy. USDA-ARS, St. Paul, MN. Report Period: 7/90-5/91. (*Now, South Dakota State Univ)

A laboratory robotic system has been successfully used to automate characterization of sorption-desorption of pesticides in soils. For instance, sorption-desorption of atrazine and two soil metabolites has been determined in different soils. The metabolites were absorbed to a greater extent than atrazine and then did not desorb from soil. Thus the two metabolites would not leach to ground water. Freundlich constants (Kf) for the absorption of atrazine on various smectite minerals ranged from 0 to 1334 and increased with decreasing layer charge of the smectites, suggesting adsorption of neutral species on hydrophobic regions of mineral surfaces as a primary sorption mechanism. Complexation constants (Ko) of atrazine on humic acids determined by an

equilibrium dialysis technique, increased with increasing pH, decreased ionic strength, and showed a strong influence of cation species and charge. Napropamide showed curvilinear responses with concentration and formed stronger complexes than atrazine. The results contribute knowledge on form, fate, and bonding mechanisms between pesticides and organic/inorganic substances in soil and water biosystems.

MINNESOTA, ILLINOIS, IOWA, MISSOURI, SASKATCHEWAN, & NC-202 RESEARCH COMMITTEE WEED EMERGENCE MODELING FOR A CROP/WEED BIOECONOMIC EXPERT SYSTEM. F. Forcella, Stephen Harvey, Dan Pantone, Morris, MN, D. Buhler, St. Paul, MN, E. Stoller, L. Wax, Urbana, Il, all USDA-ARS, T. Jurik, Iowa State Univ, Ames, IA, N. Jordon, N.E. Missouri State Univ, Kirksville, MO, G. Thomas, Agriculture-Canada, Regina, SK, and CSRS Regional Research Committee NC-202 reps for states of CO, IA, IL, IN, KS, OH, MI, MN, MO, NE, SD, WI. Report Period: 1/90-7/91.

Seed accessions of major Corn Belt weeds were collected in 1990 across the region to be used to generate emergence models that are state-specific, or regional, depending upon genetic variability of the species. To date, validated emergence models have been developed for velvetleaf, lambsquarters, green foxtail, yellow foxtail, and redroot pigweed. Additional species will include cocklebur, giant foxtail, nightshade, kochia, jimsonweed, purple morningglory, common ragweed, giant ragweed, and sunflower. The models accurately predict daily emergence from weed seedbanks. This information can be used to determine optimum time of seedbed preparation, thereby controlling weeds without herbicides. The models also interact with a bioeconomic model, WEEDSIM, providing density estimates of weed seedlings. This information allows objective decisions concerning the necessity of weed control by chemical application and tillage.

MISSISSIPPI COTTON IRRIGATION AND THE EFFECTS ON HERBICIDE MOVEMENT, PERSISTENCE, AND CARRYOVER. C. E. Snipes, H. C. Pringle III, Mississippi State Univ, and T. B. Moorman, Ames, IA, M. A. Locke, T. C. Mueller, Stoneville,MS, all USDA-ARS. Report Period: 6/90-4/91.

A rapid, sensitive method has been developed for the determination of fluometuron and its soil metabolites in 4 soil types. Fluometuron recoveries from fortified soils were > 90% in each of the four soils. Average percent relative standard deviation of Dundee soil extracts were 5.3% for fluometuron and < 8% for each metobolite. The limit of detection for fluometuron and each of its soil metabolites was 25 ng/g soil. The new method has improved cost effectiveness without sacrificing sensitivity. Preliminary analysis of soil-core samples taken in 1990 has indicated that only low levels of fluometuron (0-100 ng/g soil) remain in the soil 6 months after planting. Fluometuron was not detected in subsurface samples. These findings were confirmed by field bioassay results utilizing oats as an indicator species. Laboratory experiments to determine sorption and degradation in soil profile samples collected from the field site indicated sorption was reduced in subsurface samples, as was organic carbon and soil biomass.

MISSOURI MOVEMENT AND PERSISTENCE OF PESTICIDES IN HIGHLY AGGREGATED SOILS. C. J. Gantzer, G. A. Buyanovsky, S. H. Anderson, S. Kapila, Univ of Missouri. Report Period: 7/89-4/91.

In a field experiment on Menfro silt-loam soil, the rates of transport of two pesticides--aldicarb, a "leacher", and carbofuran, with transitional qualities--were measured in the soil with preferred pathways supposedly open (dry soil) and closed (wet soil). The estimated values of the dispersion coefficients for both pesticides were as much as an order of magnitude higher for the initially wet plots as compared to the initially dry plots. For aldicarb, the estimated values for the retardation factor were approximately 33% higher for the "dry" plots than the "wet" plots. A 24-hour delay of post-application irrigation also increased retardation. For carbofuran, the estimated values of the degradation coefficient were twice as high for the "wet" plots compared to the "dry" plots. A laboratory incubation experiment with $^{14}C$-labeled carbofuran showed significantly higher degradation rates in soil collected from 0-10 and 20-30cm than in the soil below 50cm.

Pure cultures of microorganisms able to use carbofuran as a sole source of carbon, were isolated only from the upper part of the soil profile. This information can be a major factor of understanding movement.

**MISSOURI** ROLE OF PLANT RHIZOSPHERE AND ASSOCIATED MICROFLORA IN PESTICIDES DEGRADATION. G. A. Buyanovsky, G. H. Wagner, R. J. Kremer, Univ. of Missouri. Report Period: 7/90-4/91.

The hypothesis that pesticides in soil around roots (rhizosphere) undergo more intense biological influence from enhanced soil communities than in the bulk of soil is being tested. To assess the effects of rhizosphere environments on pesticides, the dissipation rate of $^{14}C$-labeled carbofuran in different proximities to roots of corn is now under study. Special containers for plant growth have been constructed and tested. These have air-tight lids, and $CO_2$-absorbent inside. Five sets of containers have been prepared: one without plants (control), four with plants. In one set, root growth is not restricted and carbofuran is dispersed in the whole volume of soil. In the last three sets, the soil is divided by two concentric vertical screens of stainless steel mesh fabric (pore diameter 31.5um). Carbofuran is injected into one of the zones in each container. The activity of the carbon respired from each zone is measured every week using the scintillation technique. A higher rate of carbofuran degradation was found in close proximity to the root system.

**MONTANA** VALIDATION OF TRANSPORT MODELS FOR PREDICTING MOVEMENT OF AGRICHEMICALS THROUGH SOILS. W. P. Inskeep, A. H. Ferguson, R. H. Lockerman, J. W. Bauder, J. S. Jacobsen, Montana State Univ. Report Period: 9/89-5/91.

Validation of solute transport models under realistic field conditions is critical for model improvement and accurate predictions of agrichemical fate in the environment. Laboratory column and field experiments have been conducted to evaluate the predictive capability of LEACHM for describing the transport of inorganic tracers and herbicides under variable soil water regimes. Results indicate that LEACHM adequately describes solute transport under our experimental conditions, provided that soil physical parameters such as air entry value, and the Campbell's exponent are accurately determined. In addition, water management practices have been shown to reduce the movement of the herbicide, dicamba. If dicamba is allowed to degrade to metabolite prior to significant water application, the potential transport of dicamba to groundwater can be essentially eliminated. We are continuing both field and laboratory experiments for a second field season comparing other herbicides commonly used in Montana.

**NEBRASKA** USE OF CORN TISSUE ANALYSIS TO PREDICT FERTILIZER N REQUIREMENTS. J. F. Power, J. S. Schepers, D. D. Francis. USDA- ARS, Lincoln, NE. Report Period: 1/90-4/91.

Research conducted in Nebraska and a few other states in 1990 and earlier years showed that: Corn growth and grain yield are closely correlated with N concentration in the most recent fully expanded corn leaf prior to tasseling; corn leaf-N and leaf-chlorophyll content are very highly correlated; and relative chlorophyll content can be rapidly and economically monitored by comparing hand-held chlorophyll meter readings for leaves on well fertilized control strips with those for corn in the rest of the field. Based on this information, the need for adding fertilizer N side-dressing or fertigation should be predictable from leaf chlorophyll readings, resulting in minimum quantities of fertilizer used to maintain corn yields. Several experiments in NE are in progress, along with readings on corn experiments in other states, to determine how soon use of this technology is reflected in reduced ground water nitrate concentrations. When perfected this technology will improve efficiency of N use, and greatly improve the accuracy of environmentally sound N recommendations made by Extension Agents and other farm advisors

NEW YORK MAPPING GROUNDWATER CONTAMINATION POTENTIAL USING INTEGRATED SIMULATION MODELLING AND GIS. R. J. Wagenet, R. B. Bryant, S. D. de Gloria, Cornell Univ. Report Period: 7/89-4/91.

Procedures were developed for using soil, climate, land-use and terrain data in conjunction with a GIS to select and characterize agricultural areas which may be a source of pesticide leaching. A computer simulation model (LEACHM) was used to evaluate leaching potential for each soil/climate combination. Routines were developed to translate soil survey information to model input data. A representative rainfall distribution was selected for each climate region using leaching indices for each of twenty years of historic climate data. A typical year was selected using leaching indices which reflected both distribution and amount of rainfall. A pilot project conducted for Connecticut and Rhode Island evaluated the leaching hazards of atrazine, cyanazine and pendimethalin applied to a corn crop on the spectrum of soil and climate combinations in the region. This study highlighted the importance of some arbitrary assumptions that were necessary regarding lower boundary conditions and organic matter distribution in the soil profile.

NEW YORK ELECTROCHEMICAL TREATMENT OF PESTICIDE WASTEWATER. A. T. Lemley, Cornell University. Report Period: 6/90-4/91.

Preliminary experiments with electrochemical treatment of triazine herbicide aqueous rinsates have produced interesting and promising results. Pesticide removal of atrazine and cyanazine was not successful with electrochemical precipitation of ferrous hydroxide, but the addition of hydrogen peroxide in the pH range of 7 to 9 resulted in complete removal of the atrazine, as indicated by HPLC, and the appearance of new HPLC peaks for degradation products. Degradation conditions will be optimized for triazine and acetanilide herbicides. The kinetics of hydrolysis of methyl parathion were measured in aqueous solutions with excess base to provide a base to which column reactive ion exchange treatment can be compared. Preliminary results from the column reactive ion exchange work indicate that methyl parathion is degraded in situ to its major degradation product, p-nitrophenol.

NEW YORK & MASSACHUSETTS REDUCING GROUNDWATER POLLUTION: A SYSTEMS ANALYSIS WITH MODELS OF PESTICIDE TRANSPORT AND INTEGRATED PEST MANAGEMENT. C. A. Shoemaker, G. White, Cornell Univ, and D. N. Ferro, Univ of Massachusetts. Report Period: 9/90-4/91.

The goal of this project is to perform a "holistic" or systems analysis of source control of pesticide pollution by evaluating the effect of a given pesticide program on groundwater pollution, and on crop yields and net income to the farmer. In this analysis three models will be used: 1) a model of the movement of pesticide through the soil and potentially into groundwater, 2) a model of the dynamics of an insect pest, Colorado potato beetle, 3) a model of the growth of the potato plant that incorporates the effects of defoliation. All of these models depend upon weather conditions, and upon the type and timing of pesticide application. In order to evaluate pesticide movement, the RUSTIC model (developed by EPA) had to be extensively modified in order to enable us to run it on the Cornell supercomputer. In addition, the insect model will have to be modified to consider the effects of residual level of pesticide on pest survival rates. Field work to obtain these new parameters has been planned during this period and will be implemented in Summer 1991. Residual activity, under field conditions, of several insecticides will be determined by bioassay for M-One, M-One Plus, Asana, Vydate, Thiodan and Kryocide.

NEW YORK INTERACTION OF PREFERENTIAL FLOW AND BIODEGRADATION IN HETEROGENEOUS SOILS. T. S. Steenhuis, M. Alexander, B. Pivetz, J. Kelsey, Cornell Univ. Report Period: 7/90-4/91.

The current understanding is that pesticides moving relatively fast by preferential flow through macropores in soil do not degrade. However, all ingredients for significant biodegradation, such as organic matter, oxygen, and water, are available. The goal of this research is to quantify the amount of macropore flow and biodegradation as well as develop models that can use the

information. Preliminary results indicate that after the organic chemical flows through a new flow path, or maybe at a higher rate through the same flow path, an initial flush of the organic chemical will leach to groundwater. However, after a rather short time, the chemical concentration decreases to the background levels indicating that the microorganisms that are degrading the chemical build up rather quickly. This is in accordance with field experiments where the chemicals are detected in groundwater shortly after a rainfall event but are absent during the next sampling period.

NEW YORK PROTECTING GROUNDWATER FROM NITRATE ON DAIRY FARMS IN THE NORTHEAST. R. J. Wagenet, S. D. Klausner, R. A. Milligan, Cornell Univ, and S. R. Kaffka, Sunny Valley Corp., New Milford, CT. Report Period: 4/90-4/91.

The first year of field work has been completed. Yield response of orchardgrass to various rates of N--0,75,150,300,450 kg/ha--from several sources, including fertilizer and liquid and bedded manure, was determined. Soil and plant samples were collected to characterize changes in soil nutrient levels and forage quality. Plant growth was monitored at 15-day intervals and groundwater was sampled every 10 days to study nitrate movement. Samples are undergoing analysis, after which the simulation modeling will be performed. LEACHM, the N transformation and leaching model, has been expanded to include several different pools of organic C and N, namely, humus, easily degradable faeces, and less easily degradable plant litter. Initial simulations have focused on sensitivity studies in order to ascertain the relative importance of various measured parameters. The field studies showed that the recovery of applied N by orchardgrass was directly related to N availability from the three sources. Recovery was highest for commercial fertilizer and lowest for bedded manure. Data from an experiment that focused on the fertilizer N equivalent of manure, and development of a decay series for organic N are being analyzed.

NORTH CAROLINA GROUND WATER CONTAMINATION POTENTIAL USING MODELS, GIS, AND REMOTE SENSING. S. Khorram, R. L. Huffman, J. W. Gilliam, H. A. Devine, North Carolina State Univ. Report Period: 7/90-4/91.

A procedure has been developed for combining modern remote sensing technology and GIS characterization of physical and chemical properties of soil and water with water and chemical transport models, for determining groundwater contamination potential and its spatial distribution. A comprehensive database, integrating remotely-sensed data with conventional map form and tabular data in a spatial and/or temporal database context, will be applicable to hydrologic studies. This includes: determining leaching or erodibility indices; improved procedures for estimating water balance on sub-basin or watershed scales; determining potential pesticide application rates; and characterization of the movement and dissipation of pesticides or other chemicals; estimating and mapping the depths to water tables; simulating the effects of various land use or management practices on leaching, ground water contamination, or depth to water table; predicting the occurrence of and mapping recharge areas; economic analyses of various water dependent activities that may be affected by ground water contamination; and analyzing policy or regulatory implications on ground water.

NORTH CAROLINA EFFECTS OF WATER TABLE MANAGEMENT ON GROUNDWATER QUALITY. R. W. Skaggs, J. W. Gilliam, T. J. Sheets, North Carolina State Univ. Report Period: 6/90- 4/91

A field study was conducted to determine the fate of granular aldicarb (Temik) in no-till soybean plots with water-table-management treatments of: free (conventional) drainage, controlled drainage, and subirrigation. In nine sampling rounds, 652 soil and water samples were collected in 6 months. Water samples were obtained from 45 monitoring wells, 2 irrigation wells, 6 surface runoff collectors, 9 subsurface drains and the outlet drainage ditch. Soil samples were taken in six inch intervals to a maximum depth of 36 inches.

No aldicarb was detected in the soil or water samples taken 119 days after application. No aldicarb was detected in soil samples after day 61. No aldicarb was ever detected in the irrigation wells. The aldicarb concentration in shallow observation wells seemed to peak at less than 3.5 ft deep by

day 20, with an average concentration of approximately 10 ppb. Aldicarb concentrations in the subsurface drainage water for the free drainage plot peaked on day 20 with an average of 20 ppb; whereas, the maximum concentration for the controlled drainage plot was 10 ppb.

OHIO EFFECT OF SORPTION ON FATE OF PESTICIDES IN SUBSURFACE ENVIRONMENTS. S. J. Traina, G. K. Sims, T. J. Logan, Ohio State Univ and, S. A. Boyd, Michigan State Univ. Report Period: 6/89-4/91.

During the first phase of the project, considerable work has been done to develop a working protocol by which biodegradation of pesticides can be investigated in the presence of both clay and humic substances. For this purpose, pyridine has been chosen as a testing compound. Optimal experimental conditions have been selected and the degradation kinetics of pyridine by micrococcus has been investigated. Pyridine degradation was unaffected by hectorite but enhanced by a commercial humic acid at pH 7. However, at pH 5, the degradation was favored in the presence of hectorite but was strongly adversely affected by the humic acid. At an intermediate pH, adsorption of pyridine by either clay or humic acid inhibited pyridine degradation. It is concluded that at lower pH, hectorite may have protected micrococcus cells from the harmful effect of proton, but the presence of humic acid may have remarkably reduced the availability of pyridine.

OHIO SURFACE-SUBSURFACE WATER AND CHEMICAL MOVEMENT AND INTERACTIONS ON AGRICULTURAL WATERSHEDS. J. V. Bonta, W. M. Edwards, L.B. Owens, USDA-ARS, Coshocton, OH. Report Period: 1/90-4/91.

Initial characterization of a hydrologically isolated 7-acre study area, known as Urban's Knob (UK), is ongoing. A new soils map was made, and a set of monitoring wells has been installed. Soils have an impeding layer in the soil profile at lower elevations of UK, but tend to be well-drained at the top. The information suggests that water is perched in the soil profile as well as on the #6 clay. The #6 clay layer appears to be impervious more in the center of the hilltop than at the outcrop. The #6 clay was shaped like a small valley, funneling ground water to a spring. Annual runoff totals on two gaged watersheds on UK are noticeably different, leading to the conclusion that factors affecting runoff vary greatly over short distances. Annual rainfall can decrease 0.03in/ft of elevation increase. This observation suggests that precipitation inputs to UK need to be studied in detail. Watershed processes are being studied in relation to water chemistry, water movement, and interactions between surface and ground waters.

OHIO WATER TABLE MANAGEMENT FOR CROP PRODUCTION AND GROUND WATER QUALITY PROTECTION. N R. Fausey, R. L. Cooper, Columbus & Wooster, OH, and A. D. Ward, T. J. Logan, Ohio State Univ. Report Period: 1/90-4/91

At Wooster, OH, subirrigation is used to maintain permanent high water table at 25 cm depth from June 20 to September 30. Crop varieties, planting date, fertility, weed and insect control are managed for yield potentials of 240 bu/acre corn and 80 bu/acre soybeans. Water quality of drainage discharge water and ground water is monitored for nitrate, atrazine and metolachlor. Corn and soybeans are grown in rotation with both crops present every year. A second site at Hoytville, OH is under construction. The 1990 yield of corn was 187bu/a and soybean was 53bu/a. The water quality analyses are not complete but indicate high concentrations of nitrate and metolachlor are reaching the shallow ground water. This wetter than normal growing season required cycling the water table management system from subirrigation to drainage 8 times to keep the water table from remaining too high. Analysis of 1987-89 water quality data from the Wooster site shows that the lowest concentrations of chemicals and highest yields were found in the shallow ground water where the highest water table was maintained.

**OHIO** ASSESSING AND MODELING WATER QUALITY BENEFITS OF WATER TABLE MANAGEMENT SYSTEMS. A. D. Ward, T. J. Logan, E. S. Bair, Ohio State Univ, and N. R. Fausey, USDA-ARS, Columbus, OH. Report Period: 7/90-4/91.

The hydrologic components of the ADAPT model have been modified and tested. It gave good estimates of surface and subsurface flows from a long term field experiment at Castalia, Ohio. The linking of the pesticide migration algorithms to the hydrologic components is in progress. The revised model will soon be tested with water table management data from three locations in Ohio. Data from a high yield soybean study at Wooster shows the subirrigation produced significant soybean yield increases. The best responses were obtained with water table elevations within 0.25 to 0.50 m of the ground surface. High concentrations of metolachlor were also recorded in drainage discharges and the perched water table. The results show that metolachlor movement to the ground water is a function of the proximity of the water table to the surface, precipitation within the first few weeks after application, and preferential flow. Preferential flow field research will be initiated this summer. An analysis for the Fremont and Custar locations will be conducted next year.

**OKLAHOMA** AGRICULTURAL CHEMICAL IMPACT EVALUATION AND MANAGEMENT SYSTEM. D. L. Nofziger, C. T. Haan, Oklahoma State Univ, and A. G. Hornsby, Univ of Florida. Report Period: 6/89-4/91.

A computer-based system has been developed whereby an extension or SCS specialist, a policy-maker, or a manager can specify a cropping system including water and chemical management practices for a region of interest and quickly obtain an estimate of the potential for ground water contamination from the chemical. This estimate will incorporate local soil, geological, and climatic conditions. This system was developed by interfacing a chemical transport model to a geographical information system (GIS) and developing a weather interface for the model. Because weather variability has major impact on ground water pesticide loading, results are presented in terms of the probability of exceeding some loading rate or the EPA health advisory level. The system was applied to selected hydrologic units in Oklahoma and Florida. The system has been demonstrated to federal, state, and local agencies, presented at numerous national meetings including the Water Technology Board of the National Academy of Science, and used in training courses.

**OREGON** NON-POINT SOURCE POLLUTION AND AGRICULTURAL PRACTICES. L. L. Boersma, R. G. Mason, Oregon State Univ. Report Period: 9/89-4/91.

Arrangements were made with 150 farmers to maintain a diary of all farming activities on a specific parcel of land, starting January 1, 1990 and ending December 31, 1990. Farmers were in two counties, one in Western Oregon--a high rainfall area, and one in Eastern Oregon--a low rainfall area. We succeeded in obtaining an accurate and complete set of diaries from 120 of the 150 cooperators. The information has been entered into a computer data base, and analysis of the results is in progress. Preliminary analysis shows the wide range of chemicals being used, the distribution of use throughout the year, differences in use as a function of soil type and geographic area. The general perception about use of agricultural chemicals on farms, as it seems to exist in the popular and scientific literature, is incomplete and often exaggerated.

**OREGON** FATE AND CYCLING OF $^{15}$N-LABELLED DAIRY MANURE. D. D. Myrold, J. A. Moore, M. J. Gamroth, Oregon State Univ. Report Period: 7/90-4/91.

The kinetics of $^{15}$N-labelling were studied and quantified. Based on this information, several kilograms of $^{15}$N-labelled manure were produced. The $^{15}$N-labelled manure is being fractionated to study uniformity of labelling. Field microcosms have been designed and are being installed. The first application of $^{15}$N-labelled manure is scheduled to be applied by mid-May, 1991 when measurements of N-cycling will begin. These studies are the basis of two upcoming presentations at national meetings and will result in a publication of results.

**PENNSYLVANIA** USE OF MICROORGANISMS OR ENZYMES FOR DECONTAMINATION OF PESTICIDE-POLLUTED SOIL AND WATER. Jean-Marc Bollag, Shu-Yen Liu, Pennsylvania State Univ, Report Period: 9/89-3/91.

Microbial detoxification of pesticides may offer a promising alternative to existing physical-chemical treatment methods. We investigated a strain of Streptomyces sp. which can transform metolachlor in a liquid medium for its ability to decontamination herbicide treated soil. The present study has demonstrated the feasibility of transforming metolachlor through the inoculation of a Streptomyces sp. into sterile soil; however, attempts were unsuccessful with the native soil. Our results suggest that while a single organism may not be able to completely biodegrade metolachlor, a microbial population or a combination of microorganisms and abiotic factors is able to mineralize the herbicides.

**PENNSYLVANIA** NITRATE FERTILIZER RATE AND MANURE EFFECTS ON NITRATE LEACHING LOSSES. R. H. Fox, J. M. Jemison, D. D. Fritton, Pennsylvania State Univ. Report Period: 4/88-4/91.

A field experiment was conducted with zero-tension lysimeters to determine the concentration of nitrate in the leachate below the root zone of corn as a function of nitrogen (N) fertilizer rate and dairy manure. The volume of leachate collected in the 18 lysimeter pans was highly variable, but the concentrations of nitrate within treatments were less variable. The flow-weighted average nitrate-N concentrations in the leachate ranged from 4.4 mg/L after no fertilizer or manure for three years to 24 mg/L with N added at rates of 200 kg/ha as fertilizer or manure, plus fertilizer N as 100 kg/ha in 1989. The nitrate-N concentrations at economic optimum N rates were 21 and 24 mg/L in 1989 and 15 and 17 mg/L in 1990 for the non-manured and manured treatments, respectively. The collection efficiency of each pan was calculated by comparing the volume of leachate or bromide tracer collected as compared to the predicted leaching loss. The average efficiency was 54% with a range of from 13% to 92%. By adjusting for pan efficiencies we found that approximately 30% of the fertilizer N was lost as leachate at economic optimum N rates.

**PENNSYLVANIA** SOIL MANAGEMENT OF RESIDUAL MANURE NITROGEN AFFECTING NITRATES IN GROUNDWATER WITHIN LIMESTONE TERRAIN IN LANCASTER CO., PA. D. E. Baker, A. T. Phillips, E. Lotse, C. S. Baker, L. Marshall, M. K. Amistadi, Pennsylvania State Univ. Report Period: 7/90-4/91.

Animal manure N applied to fields in the study area is generally greater than removed by field corn grain or silage. Results have shown that corn silage and grain yields and gravitational water $NO_3$-N were significantly correlated with soil profile mineral N ($NH_3$-N + $NO_3$-N). Water $NO_3$-N at a depth of 4 feet in the profile was higher in plots receiving fertilizer N than for those receiving manure-N, but yields were equal. The difference could be due to greater immobilization of N in manured than in fertilized plots. For 9 field trials conducted in 1990, net N mineralization for control plots ranged from 77 to 506 kg N/ha. The mineralization of residual N met the crop nitrogen requirement at over 70% of the fields monitored. Thus, either the applications of manure must decrease or a carbon source must be added to immobilize N and decrease $NO_3$-N in gravitational water. Sawdust slightly increased yields in 1990, but was not effective in reducing the availability of residual, available N in these soils. The use of a more bioavailable source of carbon is planned for 1991.

**PENNSYLVANIA** MICROENCAPSULATION AND ADJUVANT EFFECTS ON HERBICIDE LEACHING AND PERSISTENCE. J. K. Hall, N. L. Hartwig, R. O. Mumma, L. D. Hoffman, Pennsylvania State Univ. Report Period: 7/90-4/91.

Construction of the field site, appropriately instrumented for use in evaluating mobility of herbicides co-applied with polymeric adjuvants or as microencapsulated formulations, was completed by July,1990, but too late for a corn crop that year. Greenhouse bioassays and chemical

assays of soil collected from the first rotation study--corn for 2 years, followed by oats seeded with alfalfa for 1 year--are underway. This type of field research devoted to agro-environmental issues should encompass at least three years of study; therefore, additional time may need to be requested so that three full crop growing seasons may be covered in this work. A graduate student will join the project this June, after which he will devote his research efforts to the primary objective of quantifying herbicide leaching losses within the corn root zone.

PENNSYLVANIA ENVIRONMENTAL TRACING OF CHEMICALS AND WATER FLOW PATHWAYS IN CROPLAND WATERSHEDS. H. B. Pionke, USDA-ARS, University Park, PA. Report Period: 1/90-4/90.

Rainfall, streamflow, shallow well, seepage, and soil water samples were collected from the Mahantango Creek Watershed continuously from May 1 to June 30, 1990 and analyzed for heavy isotope of oxygen ($^{18}O$) and selected chemical tracers, including nitrate ($NO_3$), chloride (Cl), silicon dioxide ($SiO_2$), sulfate ($SO_4$), and sodium (Na). Four major storm events were intensively sampled. Piezometers and wells distributed over the watershed were completely sampled once during August 1990 for analyses of chemical tracers, $^{18}O$, tritium, and radon, to determine how these parameters vary with groundwater position in the watershed. These chemical and isotopic analyses are not yet complete. The initial 1989 sampling and survey phase of the different flow components to provide the isotopic and chemical basis for subsequent experimentation is now complete. Preliminary results show that $^{18}O$ and the chemical tracers $SO_4$ and $SiO_2$ provide quantitative and comparable measures of the surface runoff and groundwater components of storm stream flow with the groundwater component being dominant.

SOUTH CAROLINA & NORTH CAROLINA TERRAIN CONDUCTIVITY TO QUANTIFY IMPACT OF FARM LAGOONS UPON GROUNDWATER QUALITY. D. E. Brune, R. O. Hegg, R. K. White, Clemson Univ, and P. W. Westerman, L. M. Safley, R. L. Huffman, J. C. Barker, North Carolina State Univ. Report Period: 6/89-4/91.

Research is underway to develop a dependable data base and interpretational procedure to allow for the use of electromagnetic terrain conductivity survey (EM) as a tool to delineate zones of impact, and quantify the magnitude of impact of intensive animal (confinement) agriculture upon the quality of local groundwater supplies. Detailed EM surveys have been conducted on 3 lagoon sites in NC and 6 sites in SC. Plumes of increased subsurface conductivity have been identified and bore holes installed. Soil analysis has produced data yielding a correlation between soil pore water conductivity and the summation of nitrate, sulfate, bicarbonate and chloride ions. This anion model has been combined with a second model, of bulk conductivity vs. moisture content, to produce a model relating groundwater ionic concentration to terrain conductivity. Predicted EM readings are currently being correlated to actual in-field EM results. In addition, a sensitivity analysis is being conducted to determine the relative influence of soil particle size, depth to groundwater and depth to bedrock on the EM signal.

SOUTH CAROLINA & KENTUCKY GROUNDWATER QUALITY AS AFFECTED BY PREFERENTIAL FLOW IN STRUCTURED SOILS. V. L. Quisenberry, B. R. Smith, Clemson Univ, and R. E. Phillips, Univ of Kentucky. Report Period: 6/89 4/91.

Macropore flow of water and chloride was measured in two well-structured soils: the Maury silt loam in Kentucky and the Cecil sandy loam in South Carolina. Undisturbed blocks (30 by 30 by 30 cm) of each were taken in meadow and placed on an apparatus that permitted outflow to be collected in 100 equal segments, while maintaining a small negative pressure at the bottom soil boundary. Water tagged with a chloride tracer was applied to the surface at four rates. In both soils about 75% of the water and chloride flowed through 25% or less of the volume. One segment (1/100 of the cross-sectional area) in the Maury accounted for 15 to 20% of the total outflow. Displacement of initial soil solution was greater in Cecil sandy loam than in Maury silt loam. Data suggest that channelized flow commenced within the plow layer (Ap) horizon of the Maury and at the Ap-Bt interface in the Cecil. The three-dimensional geometry of the pore systems is being described

through image analysis techniques. Functional relationships will be developed between pore geometry and macropore flow and permit us to develop realistic field-scale transport models that include macropore flow.

SOUTH CAROLINA Water Quality Evaluation for Duplin County Demonstration Project. P. G. Hunt, K. C. Stone, USDA-ARS, Florence, SC. 7/90-4/91.

In conjunction with the Soil Conservation Service/Extension Service (SCS/ES) Demonstration Project in Duplin County, NC, stream waters have been sampled continually since September 1, 1990, by use of automated samplers at three sites on Herrings Marsh Run. The stream has both a clean and a polluted branch and the main, combined channel continually discharges elevated levels of N and P. At times, ammonium, nitrate, and ortho-phosphate in the polluted branch were greater than 30, 8, and 3 mg/L, respectively. The density of swine farms along the polluted branch and lack of swine or poultry farms on the clean branch suggest that the contamination can be reduced or eliminated with improved waste management operations. Domestic well sampling in the Duplin country area indicates that more than 20% of the wells had elevated nitrate concentrations and traces of pesticides.

SOUTH DAKOTA DEVELOP TECHNOLOGIES FOR MANAGING CORN ROOTWORM POPULATIONS WITH REDUCED INSECTICIDE INPUTS. D. R. Lance, W. D. Woodson, G. R. Sutter, USDA-ARS, Brookings, SD. Report Period: 3/90-4/91.

To reduce damage by larvae of Diabrotica beetles (corn rootworms), growers annually apply highly toxic soil insecticides (1-1.3 lbs AI per acre) to over 20 million acres. Applications are made automatically at planting to most fields in which maize is grown year after year and even to some fields of "first year" (rotated) maize. New technologies utilizing semiochemicals may drastically reduce this usage. When broadcast over maize fields, baits containing minute amounts of a potent feeding stimulant (<0.05 oz/ acre) reduced numbers of rootworm beetles by up to 98% but contained only 2% of the insecticide used in a conventional application. A newly developed trap that is baited with food-related attractants showed promise as a tool for determining if populations of rootworm beetles are below economically damaging levels. Also, a prototype knowledge-based system for PC's is being developed to help growers manage rootworm populations.

TENNESSEE THE EFFECTS OF TILLAGE AND CROPPING SYSTEMS ON TRANSPORT OF NITRATE THROUGH HETEROGENEOUS SOILS. G. V. Wilson, D. D. Tyler, J. Logan, Univ of Tennessee, and G. W. Thomas, R. L. Blevins, Univ of Kentucky. Report Period: 5/90-4/91.

The general objectives are to determine the effects of cropping systems and tillage practices on nitrate movement and to evaluate the preferential flow under such systems by comparing leachate measurements from three sizes of lysimeters. Installation of all lysimeters was completed by May 1990. Leachate has been collected following storm events since that time. Nitrate concentrations and the quantity of subsurface flow have been recorded. Soil samples have been collected under each cropping system, in four replications, prior to fertilizer applications in both Tennessee and Kentucky, and nitrate and ammonium concentrations determined. Weather stations that record rainfall intensities at 5 minute intervals and monitor soil temperatures at six depths have been installed at research sites. In Tennessee, ponded and tension infiltration measurements, and dye staining patterns, have been made. The severity of nitrate leaching under various cropping systems will be quantified in situ and the mechanisms controlling the field-scale leaching will be identified.

TEXAS HYDRAULIC CONDUCTIVITY AND MACROPORE FLOW OF WATER IN RELATION TO SOIL STRUCTURE. K. J. McInnes, L. P. Wilding, C. T. Hallmark, W. L. Bland, M. L. Wolfe, Texas A&M Univ. Report Period: 7/90-4/91.

Hydraulic properties based on in situ measurements, as important soil characteristics, should be part of the information displayed on soil survey maps. This project is: improving models of soil hydraulic behavior as a function of soil structure/macroporosity morphological properties;

quantifying the significance of macropores as preferential flow paths for water and pollutants in highly structured soils; combining model results with the existing information in soil surveys through GIS. Hydraulic measurements have been made on several vertic soils in the Claypan land resource area, and are presently being collected on a Branyon clay. A numerical model of the infiltration and sorption processes has been developed to help in extracting hydraulic information (macropore distributions) from field infiltration and sorption data. Correlation of results with soil structure/macroporosity morphological properties has begun. The information being gathered is allowing quantitative measurements of hydrologic behavior to be related to data on soil resources that are available through the National Cooperative Soil Survey Program, and, thus, provide critical information for evaluation of soil resources relative to nonpoint and point source groundwater pollution.

UTAH OPTIMIZING IRRIGATION MANAGEMENT FOR POLLUTION CONTROL AND SUSTAINABLE YIELDS. L. M. Dudley, R. J. Hanks, R. C. Peralta, Utah State Univ. Report Period: 6/89-4/91.

A mechanistic water flow and salt transport model has been developed. We have used the model to make long-time estimates of yields and water budgets under no leaching conditions. Model predictions agree with field observed yield trends. The model predicts that leaching is not required to maintain alfalfa yields even when using relatively saline water. We have observed no yield loss on alfalfa irrigated for 14 years without leaching and the model predicts that this can be continued for at least another 10 years. Our results suggest that the traditional model for managing saline irrigation water on well drained soils by leaching is in error. If leaching is eliminated, considerable water saving and reduced ground water degradation could be realized. An optimization model of water flow has been coded and verified. The equations for modeling salt transport have been derived and this portion of the optimization model is being calibrated. The optimization and mechanistic models will be used to develop irrigation water management schemes that maximize salt storage in the soil profile.

UTAH ECONOMIC INCENTIVES FOR MANAGING NON-POINT PESTICIDE POLLUTION OF GROUNDWATER: A PROTOTYPE APPLICATION. T. F. Glover, H. H. Fullerton, R. C. Peralta, D. G. Alston, H. Deer, R. D. Ramsey. Utah State Univ. Report Period: 6/90-4/91.

A computer management model has been developed which computes optimal sustained groundwater yield strategies for complex stream/aquifer systems. The model has been applied to the 3-layer aquifer along the eastern shore of the Great Salt Lake. Several maximum sustained groundwater yield strategies have been developed to show the effects of volumetric management extraction. Increased pumping in the urban areas reduces water available for agriculture and biota and reduces discharge from springs and wells that currently flow under artesian pressure in the simulations using the model. Water quality (pesticide inflow) and economic constraints are now being imposed on the system to simulate the effects of the constraints on surface irrigation technology and pumping which can be achieved by agricultural and urban interests in the area. Results suggest that irrigation technology is slightly affected but alternative (and more costly) pesticides should be used.

VERMONT EFFECTS OF CORN MANAGEMENT SYSTEMS ON NITRATE LEACHING POTENTIAL. F. R. Magdoff, W. E. Jokela, J. C. Clausen, Univ of Vermont. Report Period: 8/89-4/91.

The 1990 field season demonstrated that the pre-sidedress soil nitrate test (PSNT) performed favorably. With the PSNT for the no manure (M) treatment, the fertilizer recommendation was 56 kg/ha less than for the Routine Recommendation System (RRS). Although corn silage yields were not signficantly decreased by the lower rate of fertilization, the PSNT (no M) treatment, had 48 kg less profile nitrate ($NO_3$-N) at 0-1.2m depth after harvest than the RRS treatment. The PSNT with manure treatment had a slightly higher yield than PSNT without manure, but residual $NO_3$-N was not different. Compared to the Check treatment, other N management systems had higher yields and higher residual $NO_3$-N. Total plant N was higher for RRS and PSNT (+ M) than

for PSNT (No M) and lowest for the check treatment. Compared to either PSNT treatment, the RRS treatment resulted in a 50% increase in nitrate leaching potential without significantly increasing yields.

VIRGINIA SOIL MINERAL NITROGEN AS A PREDICTOR OF NITROGEN FERTILIZER NEED OF WINTER WHEAT. M. Alley, P. C. Scharf, Virginia Polytechnic Institute. Report Period: 6/90-4/91.

Winter wheat is second only to corn in terms of N fertilizer applied. Over-application of commercial N fertilizers and animal wastes has been identified as a major source of nitrate contamination of groundwater and eutrophication of surface waters. Experiments are being conducted to develop a winter wheat N fertilization system that is based on soil nitrate levels in individual fields. This system will enable growers and advisors to make more precise N fertilizer applications on a field-specific basis, and thus reduce the potential for water quality degradation from excessive levels of soil nitrates. The improved fertilization system has the potential to influence N fertilizer applications on 300,000 to 400,000 acres yearly in Virginia alone. Several million additional acres of wheat in other mid-Atlantic and Southeastern states with similar soils and climatic conditions could also be positively affected with the development of this improved system for recommending N fertilizer applications.

VIRGINIA COMPOSTING AS A MEANS TO DISPOSE OF PESTICIDE WASTE. D. F. Berry, D. E. Mullins, G. H. Hetzel, R. W. Young, Virginia Polytechnic Institute. Report Period: 7/90-5/91.

The lack of adequate disposal methods for unused concentration and dilute pesticide formulations including rinsate solutions is a serious concern. We are developing a pesticide waste disposal system beginning with concentration of pesticide from rinsate or runoff waters, associated with agrichemical distributorship mixing and wash down pads, onto sorbents (i.e., peat moss). Following concentration, pesticide-laden sorbents are composted and the pesticide degraded by microorganisms. Atrazine, in an initial concentration of 100 mg/kg (ppm) dry wt sorbent, and carbofuran at (1500 ppm) were degraded in our system within 100 days. Methods for pesticide waste disposal are needed, especially for small farm operators and distributors who require an inexpensive, easy to operate disposal technology. We propose to field test our system as a next step towards implementation.

WASHINGTON DEVELOPMENT OF A SPATIAL DECISION SYSTEM FOR FARM MANAGEMENT OF NITROGEN FERTILIZER APPLICATIONS. D. J. Mulla, G. S. Campbell, Washington State Univ. Report Period: 6/89-4/91.

Soil properties, crop growth patterns, and irrigation applications were measured at forty plots in a 57 ha commercial potato farm. Each plot was sprayed with a potassium bromide tracer on May 24, 1990. Soil from each plot was sampled to a depth of 90-120 cm in 10 or 15 cm increments at hill crest and furrow midpoint positions on three sampling dates, namely; June 9, June 22, and July 15. Cumulative measured sprinkler irrigation depths for these three sampling dates averaged 84, 168, and 349 mm, respectively. On the first sampling date, bromide concentrations exceeding 15 ppm were detected as deep as 90 cm in the furrow. Highest bromide concentrations averaged over all plots on the first sampling occurred at depths of 45 cm (13 ppm) and 60 cm (16 ppm). Bromide concentrations 90 cm in the hill never exceeded 2 ppm on the first sampling. By the third sampling, bromide concentrations in the furrows averaged less than 4 ppm at all depths, indicating significant leaching losses of bromide below a depth of 120 cm. In contrast, bromide concentrations in the hills averaged over 15 ppm in the surface 0-20 cm, indicating upward movement of bromide due to plant uptake. These results suggest that spatial variability in leaching of nitrate is a serious problem in furrows of the potato field studied.

WASHINGTON MANAGING NITRATE GROUNDWATER POLLUTION FROM AGRICULTURE IN THE PACIFIC NORTHWEST. N. K. Whittlesey, Washington State Univ, and R. M. Adams, G. M. Perry, Oregon State Univ. Report Period: 6/89-5/91.

Work on this project has progressed on two fronts. At WSU the CERES crop growth models for corn, wheat, and potatoes have been modified to incorporate the uniformity and adequacy factors associated with sprinkler irrigation. The SPAW-IRRIG model has been used similarly to model alfalfa crop production. These models have been validated for the Columbia Basin region of Washington and are now being used to evaluate policy measures for controlling nitrate pollution of groundwater from irrigated crops. At OSU research has focused on the Treasure Valley region of SE Oregon. Crop simulation models for rill irrigated wheat, sweet corn, and potatoes are being calibrated and validated. Detailed soil sampling has been carried out to evaluate the effect of heterogeneous soil properties within a field on irrigation efficiency and nitrogen leachate. A simulation model for onions is now being developed and identification of current and potential management practices that influence nitrate leaching are underway.

WEST VIRGINIA BACTERIAL QUALITY OF POINT-OF-USE FILTERS USED FOR TREATMENT OF RURAL GROUNDWATER SUPPLIES. G. K. Bissonnette, J. W. Snyder, R. E. Anderson, C. N. Mains, West Virginia Univ. Report Period: 6/89-4/91.

A twelve-month field study was conducted to determine the impact of point-of-use (POU), powdered activated carbon (PAC) filters on the microbiological characteristics of 24 untreated groundwater supplies. Total coliform and heterotrophic plate count (HPC) analyses were used to assess drinking water quality. Although PAC filters did not prevent the passage of coliforms, bacterial densities were substantially reduced in effluent waters when compared with influent waters. Coliforms were not detected in most core samples removed from selected PAC filters, suggesting that coliforms did not colonize the POU devices. Nearly 75% of the water systems treated with POU filters demonstrated elevated HPC densities following overnight static periods. Effluent bacterial counts generally returned to levels detected in influent waters after flushing the static system for two minutes.

WEST VIRGINIA NEMATICIDE MOBILITY AND BIODEGRADATION: EFFECTS OF ORCHARD SOIL MANAGEMENT. J. B. Kotcon, A. J. Sexstone, D. M. Glenn, West Virginia Univ. Report Period: 5/90-4/91.

This project evaluates the influence of varying soil structure and organic matter content on the mobility and biodegradation of the nematicides carbofuran and fenamiphos. Three orchard floor management systems, clean cultivated, herbicide treated, and killed sod, were established in a newly planted peach orchard. Soil and water samples were collected after application for analysis of nematicide movement and degradation using reverse phase HPLC with UV detection. A methylcarbamate hydrolase (mcd) gene probe is being used to monitor carbofuran-degrading microbial populations in soil. Two total bacterial DNA extracts from untreated orchard soil were digested with EcoRI. Digests were separated by agarose gel electrophoresis and probed with the mcd gene probe. Hybridization at a 7.5 kb EcoRI band to one of the total bacterial DNA samples, thus demonstrating detection of the mcd gene in soil microflora prior to carbofuran application.

WEST VIRGINIA WATER QUALITY IMPACTS OF AGRICULTURE IN SOUTHEAST WEST VIRGINIA. G. C. Pasquarell, S. F. Wright, D. G. Boyer, D. P. Bligh, C. M. Feldhake, USDA-ARS, Beckley, WV. Report Period: 6/90-4/91.

The study area is extensively utilized for cattle grazing and dairy farming, and is located on a Karst landscape. It is hypothesized that this combination of land use and Karst geology presents an acute condition for groundwater contamination. Weekly sampling is being conducted in selected springs which drain large portions of the study area. Results support the hypothesis that animal fecal pollution is entering the groundwater at significant levels. Nitrate levels in these springs average between 10.7 and 14.2 ppm as nitrate. This is well above typical uncontaminated levels. The ratio

of fecal coliform to fecal strep plate counts averages between 0.7 and 1.4. This places them in the range where significant animal fecal pollution is a plausible factor. Preliminary screening for triazine pesticides indicates their presence at low (< 1.0 ppb) levels.

WISCONSIN SAFE ON-FARM DISPOSAL OF DILUTE PESTICIDE WASTES. G. Chesters, J. M. Harkin, Univ of Wisconsin. Report Period: 7/90-91.

Information was collected on nature and amounts of pesticides used on typical Wisconsin farms. Sites were identified where representative samples of pesticide wastes can be collected for analysis and experimentation. Representative herbicides and insecticides now being used have been selected for further study. Methods are being developed to analyse for parent compounds and their organic breakdown products using gas and high-pressure liquid chromatography, and their inorganic breakdown products, where appropriate, to provide means to test efficiency of chemical and photocatalytic treatments designed to convert pesticidal wastes into forms safe for on-farm disposal. A sophisticated laboratory-scale water-cooled photocatalytic apparatus has been constructed and will be used to test the power input, exposure times, etc. required for complete mineralization of active ingredients as functions of the semiconductor photocatalytic ceramic membranes, flow rates, etc. A simpler uniformly illuminated exposure system has been constructed to perform preliminary tests to optimize membrane composition and determine if pesticide inert ingredients and farm-derived contaminants might interfere with processing of dilute pesticide wastes. Parallel tests are assessing whether on-farm chemicals can be used to treat wastes for direct disposal.

WISCONSIN & NEW YORK USING GROUND PENETRATING RADAR TO IMPROVE MONITORING AND PREDICTING PREFERENTIAL SOLUTE MOVEMENT IN SANDY SOILS. K-J. Samuel Kung, R. T. Chin, J. Zachman, S-H Ju, Univ of Wisconsin, and T. S. Steenhuis, J-Y. Parlange, L. M. Cathels, J. Boll, Cornell Univ. Report Period: 7/90-4/91.

During the first year of the study, emphasis has been on developing and calibrating a 2-D finite element computer model and GPR protocol. The results from the computer model showed that the Richards' equation cannot simulate the funnel phenomenon. This is because the Haine's jump, occurring along the boundary with disrupt textural discontinuity, is not considered in Darcy's Law. In a hypothetical vadose zone with randomly-distributed funnels, the simulated results demonstrate that the downward velocity distribution reaches a log-normal pattern. This finding shows that it is the funnel density instead of the exact location of the individual funnel that will determine the final stochastic flow pattern. A digital ground penetrating radar (GPR) has been purchased and is being tested for its ability to elucidate soil layers. Two software packages on how to filter out noises and false images from the raw GPR data by 3-D migration and deconvolution are being tested. A technique to reconstruct the 3-D soil layer structure from the 2-D GPR images by using the Landmark Graphic Station has been developed.

WISCONSIN MOVEMENT OF ATRAZINE AND ALACHLOR THROUGH THE UNSATURATED ZONE: MODEL CALIBRATION AND VALIDATION. K. McSweeny, B. Lowery, Univ of Wisconsin. Report Period: 6/89-4/91.

A comprehensively instrumented field research site has been established on sandy, alluvial soils, near Arena, Wisconsin. The influence of selected tillage, irrigation, and soil additive management practices on fate and transport of agrichemicals are being evaluated. The wet 1990 growing season featured several large storms during May and June that occurred after chemical application but before irrigation was started. Major findings include: evidence of very rapid transport of water through the soil profile; detections of atrazine concentrations greater than 1 ppb in soil-water below the root zone (>1m) within 40 days after application. The influence of irrigation on herbicide transport was not satisfactorily resolved because of the large amount of early season rain, which delayed the need for supplemental irrigation until late in the growing season. The field-derived data supporting laboratory data are being compiled to simulate water and pesticide movement using the LEACHM computer model.

## SELECTED GEOGRAPHIC AREAS: MIDWEST INITIATIVE
## Management Systems Evaluation Areas (MSEA)

Five MSEA were initiated in Fy 1990 as a part of the President's Initiative on Water Quality. The program is jointly conducted by USDA, USGS, EPA, the Agricultural Experiment Stations, Cooperative Extension Service, and other cooperating state and federal agencies. The intent is for continued support for a long enough period to develop information on the advantages and disadvantages of different production systems, with emphasis on water quality problems associated with corn and soybean production.

IOWA EVALUATION OF THE IMPACT OF CURRENT AND EMERGING FARMING SYSTEMS ON WATER QUALITY. J. L. Hatfield, USDA-ARS, Ames, J. L. Baker, Iowa State Univ, P. J. Soenksen, U.S. Geological Survey, Iowa City, IA, and many others. Report Period: 3/90-4/91.

Three sites have been set up in Iowa to address the objectives of the project. These sites are: The western region near Treynor on deep loess soil; the central Des Moines Lobe near Ames on glacial till soil; the northeast region near Nashua on glacial loam till soil, and and were chosen because of having the desired characteristics of soils, crops, and hydrology, and their ongoing research related to water quality. Results at Nashua with four tillage treatments and three crop rotations indicated that the yearly losses of nitrate-N ($NO_3$-N) in the shallow groundwater ranged from 30.3 to 107.2 kg/ha. There were differences in the tillage systems in $NO_3$-N and pesticide movement and concentrations in the shallow groundwater. At Nashua there was no difference between conventional and ridge-till fields in the nitrate concentrations in the soil, however, differences have been found in nitrate concentration in the base flow. Weekly samples of the stream flow concentration of nitrate, atrazine, alachlor, and metribuzin in the Walnut Creek watershed near Ames have shown large changes throughout the year in atrazine and nitrate.

MINNESOTA, NORTH DAKOTA, SOUTH DAKOTA & WISCONSIN MIDWEST INITIATIVE ON WATER QUALITY: NORTHERN CORNBELT SAND PLAINS. J. L. Anderson, J. Lamb, Univ of Minnesota, R. H. Dowdy, USDA-ARS, G. Delin, U.S. Geological Survey, St. Paul. MN, R. Knighton, North Dakota State Univ, D. Clay, South Dakota State Univ, G. Bubenzer, Univ of Wisconsin, and many others. Report Period: 7/90-4/91.

The primary objective is to evaluate the impact of an agricultural management system on ground water in sand plain settings in the four states. As data are obtained relative to the impact on ground water, the system will be modified to reduce those impacts. Specific objectives are to: (1) investigate the impacts of ridge-tillage practices in a corn and soybean cropping system on the rate of transport of atrazine, alachlor, and metribuzin in unsaturated and saturated zones; (2) determine the effects of nitrogen management by soil test; (3) characterize water flow and relate these characteristics to transport and storage of agricultural chemicals; and (4) determine the relation between ground water recharge and agriculture-chemical loading of ground water. The characterization and research installations have progressed well at the sites located as follows: The Anoka Sand Plain near Princeton, MN; the Oakes Irrigation Research Area, Oakes, ND; the Big Sioux Aquifer area, Brookings, SD; the Wisconsin River Sand Plains area.

**MISSOURI** ALTERNATIVE MANAGEMENT SYSTEMS FOR ENHANCING WATER QUALITY IN AN AQUIFER UNDERLYING CLAYPAN SOILS. Eugene Alberts USDA-ARS, A. A.'Tony' Prato, Univ of Missouri, D. W. Blevins, U.S. Geological Survey, and many others. Report Period: 4/90-4/91.

The Missouri area is located in the Goldwater Creek watershed within a claypan soil region. First year activities included selecting farming systems to be evaluated, selecting and evaluating field and research plot areas, installing equipment for research facilities, installing and developing groundwater monitoring wells, collecting and analyzing baseline water samples, designing a surface water monitoring plan, conducting topographic and soil surveys, conducting a socioeconomic survey of farmers in the Goodwater Creek watershed, developing promotional materials and informing the general public about the project. In addition, we contributed to refining the goals, objectives and procedures for the regional MSEA project.

**NEBRASKA** MANAGEMENT OF IRRIGATED CORN AND SOYBEANS TO MINIMIZE GROUNDWATER CONTAMINATION. D. G. Watts, R. F. Spalding, Univ of Nebraska, J. S. Schepers, USDA-ARS, and M. Ellis , U.S. Geological Survey, Lincoln, NE, and many others. Report Period: 5/90-4/91.

The MSEA project is on a silt loam soil in Nebraska's Central Platte Valley near the town of Shelton and is typical of furrow irrigated corn and soybean production in the Platte River Valley. Four 16-ha fields were established to represent: 1) conventional N and water management practices, 2) surge irrigation as an inexpensive way to improve water distribution and N management using soil testing for fertilizer N recommendations and tissue testing to facilitate fertigation, 3) near optimum water management using sprinkler irrigation coupled with soil testing, tissue analysis, and fertigation to attain a high level of N-use efficiency and minimize nitrate leaching, and 4) irrigated alfalfa as a scavenger crop. An adjacent buffer area was established to minimize chemical input to ground water of the management system evaluation fields. Land shaping and construction for furrow irrigation systems and installation of 4 sprinkler irrigation systems and monitoring wells were completed prior to planting the 1991 crops. Adjacent component research projects have been initiated to develop future BMPs and target technology transfer activities. Experiments underway include tissue testing to schedule fertigation, precision application of water and N fertilizers, corn and soybean rotations, scavenger crops, manure nutrient utilization, irrigation scheduling strategies, denitrification and gaseous N losses, irrigation uniformity, fate and transport of nutrients and pesticides, and decision aid tools.

**OHIO** THE OHIO BURIED VALLEY AQUIFER MANAGEMENT SYSTEM EVALUATION AREA. A. Ward, Ohio State Univ, N. Fausey, USDA-ARS, and J. T. deRoche, U.S. Geological Survey, Columbus, OH, and many others. Report Period: 4/90-4/91.

Phase 1 (first year) activities include: The design, procurement, and installation of the monitoring systems; basic site characterization; and initiating farming activities. More than 80 percent of the Phase 1 activities have been completed and several Phase 2 activities have been initiated, and most personnel have been assigned. Soil and hydrogeological site characterization studies have been undertaken and the ground water monitoring wells have been installed. Most tillage operations have been completed, planting has started, and routine data collection initiated. A regional Steering Committee of Principal Investigators has been established together with Technical Subcommittees which address management, socio-economics, ecological effects, and technology transfer. A regional project document has been prepared and Ohio has prepared a documentation manual, a Standard Operating Procedures manual, a QA/QC protocols document, and a project management infrastructure. The site overlies the Scotio River Buried Valley Aquifer near Piketon.